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REPORT ON THE AGRICULTURAL EXPERIMENT STATIONS, 1949[1]

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STATION RESEARCH AND EFFICIENT FARMING

American agriculture, like American industry, is recognized for its efficiency, initiative, and modern innovations. Farming is traditionally an independent kind of occupation. Long experience with the daily operations of the farm has stimulated desires for greater abundance with less lost time, motion, and expense.

Research conducted at the agricultural experiment stations of the individual States, Alaska, Hawaii, and Puerto Rico, has made many contributions of practical value to American farmers. Recommendations coming out of station projects have been important influences in improved agricultural efficiency. Farmers, with the aid of research, have found new and shorter ways to do things. Profitable farming has become more and more dependent on keeping up with scientific developments. In doing so, farmers have learned the value of looking to agricultural research to guide them in their farm operations. There they have a source of new scientific information as well as a proving ground for original ideas that farmers themselves may have.

Workers in agricultural research recognize that newly discovered facts and principles must be translated into practical farm operations. Farm practices must also be geared to certain economic and social forces

[1] Submitted in accordance with the requirement that the Secretary of Agriculture shall report to Congress on the work and expenditures of the State agricultural experiment stations established under the Hatch Act of 1887 and supplementary legislation. The period covered is the fiscal year ended June 30, 1949.

which can best be interpreted by the agricultural economist. Conservation of the Nation's soil resources, changing standards of living on the farm, and changes in consumer demand must be integrated with higher yields from newly developed animal and plant strains and more efficient methods of production.

Today the majority of American farmers utilize the available research information of the State experiment stations and the Department. Through close cooperation with these institutions farmers are better able to adjust their practices to meet the ever-changing demand, price, and market situation. Through adaptation and practical improvements on the land farmers are able to convert the findings of research into new methods that improve yields, cut production costs, and assure better care and lasting conservation of the soil ontheir land. Station research in problems of adjustment of production and consumption adjustment goes on side by side with research leading to improved or new methods for abundant production of the grain, milk, eggs, meat, fruits, vegetables, and other food and fiber crops consumers need and want.

Restaffing and coordination

In the 1948-49 fiscal year, experiment stations made progress in their gradual restaffing with scientific personnel which was unavailable during the war period. During that period training of the type of person needed for agricultural research practically came to a standstill. Now an increasing number of young men who have been able to complete their advanced training have been employed and are beginning to make important contributions.

There has been considerable progress, too, in bringing together various phases of research. In the laboratories, and in the field trials, emphasis has been put on closer integration. The Research and Marketing Act of 1946 has provided for expanded cooperative research effort between the stations and the Department on a well-coordinated basis. Research and extension work are being more closely integrated in an effort to speed up application on the farm of the new knowledge coming from research.

DAIRY FARMING RESEARCH

Closer cooperation between the various research departments has done much to improve conditions in the various specialized types of farming. In this annual report on the research at the agricultural experiment stations during the past fiscal year, the Office of Experiment Stations has selected the field of dairy farming as an example of the concentrated approach in research to a given farming industry.

From the variety of contributions which constitute this report, it will be observed that dairying has profited not from a single type of scientific application but from a synthesis of scientific information derived from many research sources. The soil scientists, for example, have obtained additional information on the nature of soils and the influence of lime, plant nutrients, and manures, and the effect of crop rotations on soil fertility and crop production. Plant breeders have produced superior varieties of several field crops and of grasses and legumes which have been used by dairymen in both grazing and hay production. Animal

breeders have improved the productive merit of the several breeds of dairy cattle and of cross-breeds. Nutrition research has contributed much to the better feeding of all types of dairy cattle for growth, maintenance, and milk production. The pathologists and parasitologists are protecting the herds from a multitude of pests and diseases.

The economists are studying the forces both on and beyond the farms that effect the success or failure of the dairy industry and students of rural life are beginning to throw light on the influence of rural social institutions, organizations, and service agencies in dairy-farming and other types of farming communities. The agricultural engineer is helping to increase farm incomes and to raise the level of rural living by improving the design of farm structures. The farm home is being redesigned to make it more livable for every member of the family, and relatively less expensive to build and maintain. Human time and effort are being conserved by redesigning dairy barns and other farm structures.

The agricultural engineer is not only making farming more efficient in point of production costs and labor efficiency, but is eliminating much of the hard work and drudgery which characterized early day farming. The country home, thanks to the engineer and the home economist, is becoming a good place to make a living and to live healthy, wholesome lives.

The dairy husbandmen are not only doing research in their own right but are bringing together and harmonizing the vast body of knowledge drawn from all scientific sources. Much of the research in addition to providing valuable information has called attention to the need for new and more thorough research on the unsolved problems of the several branches of the industry.

The amount of milk used per person in the United States is still far below the "adequate" dietary level recommended by the Food and Nutrition Board of the National Research Council. Interestingly enough, this is the situation as our growing population which includes a large number of children under 10 years of age, reaches 150 million. Specialists in soils, forage, pastures, agronomy, and related fields believe that we have the resources to produce the needed milk. The big problem as our scientists and practical dairy farmers see it is the high cost of production in relation to the price the consuming public is able to pay.

Scientific housing for dairy animals

One of the first considerations in the modern business of dairy farming is that of shelter and equipment for animals. Our present-day dairy barn with its specialized equipment and appurtenances has developed through the years by the process of evolution and research. Contributions to its development have been made by inquisitive farm producers, farm managers, research personnel, engineers, and industry, but most of all by the men who feed and handle dairy cows. Homemade gadgets, the ideas for which were conceived in the minds of farmers, farmers' sons, and hired hands usually had a paramount motive—to reduce drudgery. Many of these ideas were incorporated in the modern dairy barn. The process of innovation and improvement continues. New problems arising in connection with dairy housing

and equipment are constantly being tackled by State experiment stations at the suggestion of interested farmers.

One of the major questions in this country today is how more farmers can be encouraged to go into needed milk production. There are many young people in our 4–H Clubs and in the vocational schools of agriculture who like cattle and who would like to build up a dairy herd. Many of them cannot look forward to inheriting the herd they want and the well-equipped farm that must go with it. They are confronted by one major question that can mean success or failure in their lifetime career of dairy farming: "What kind of a dairy structure will insure the economic production of safe, high-quality milk that will return a reasonable profit to the farmer"?

It is recognized by everyone involved—the farmer, the engineer, the designer—that basic and fundamental information is needed to determine the functional requirements of dairy barns and related structures. This information must be based on a full understanding of all the factors that go into the production of the final product. Many years ago research workers initiated investigations in an effort to get at some of the underlying and fundamental problems. Today we know a few of the answers, but many problems are still unsolved.

Research activity in the several State agricultural experiment stations under the recent provisions for regional approach has made possible combined thinking and combined attack on some of the basic and important problems. Current activities are aimed at finding practical ways for lowering unit cost of labor, buildings, and equipment, insuring herd health, providing favorable temperature and ventilation, preventing mechanical injury to cattle, and meeting health and sanitary requirements of consumer areas. Companion investigations are designed to ascertain basic facts.

Research on effect of environment

Intensive breeding programs have solved some of the problems involved in helping the major dairy breeds to become adjusted to the climate of our important dairy regions. But numerous questions still must be answered. For example: Are there areas to which dairy farming cannot be adapted; what effects do changes in climate have on the health, productivity, and life span of dairy animals; how do humidity, temperature, ventilation, light conditions, and other physical environmental factors affect dairy animals?

It was to answer questions like these that the Psychroenergetic or Climatic Laboratory was established on the campus of the University of Missouri. There, in cooperation with the Department, the Missouri station has undertaken a study of the reaction of dairy cattle to changes in temperature. How can one tell if a cow is uncomfortable? Will she pay out in increased milk production for a warm barn in winter or a cool place to lie down in summer? The Missouri workers report that larger cows usually suffer most with the heat. Although smaller cows have a higher respiration rate than larger cows, their faster breathing helps keep down body temperature. Cows that drink more than the average amount of water in warm weather are more "resistant" to hot weather. Temperatures above 80° F. adversely affect milk production. In spite of the best possible ration, cows will soon go dry if the temperature remains around 105°.

Since cows cannot sweat freely they keep cool by reducing feed consumption and milk production. This is because most of the heat a dairy cow generates in her body comes from the digestion and assimilation of her feed. The California station, also in cooperation with the Department, is engaged in companion studies designed to investigate the natural-occurring climatic conditions as found in the dairy regions of the Imperial Valley.

Trials at the Louisiana and Kentucky stations tend to show that high temperatures are more detrimental to economical milk production than cold weather. As hot weather forces milk production down, the solid constituents in milk, except lactose, tend to rise (Missouri station records). But this is only a temporary phenomenon. Over longer summer periods the butterfat test drops or milk flow sharply declines. The vitamin A content of the milk follows the vitamin A content of the feed and is little affected by the changed metabolism caused by hot weather. Speaking of metabolism, the Michigan station found that the body demand for thyroxine is greatly reduced in hot weather.

These experiments help to explain what relation body temperature bears to the physiological processes of the cow's body and what effect environmental temperature and feed intake have on these processes. Continued research along these lines is expected to be of great practical use to the dairy farmers of the nation.

Loose-housing system

In the North Central States a cooperative project, growing out of research done earlier by some of the cooperating stations[2], indicates that revolutionary changes must be made in the housing, management, and operation of the dairy herd. Under the current system of milk production housing and labor costs are high in relation to the prices the consuming public is willing to pay for milk. This is particularly true in the northern latitudes.

The loose-housing system developed in the North Central research projects has many practical advantages. Under this system cows are not individually fastened, but are allowed to run loose in loafing sheds except for milking. At milking time they are brought individually into a milking parlor. Shelter costs are lowered; less labor is necessary; feeding and milking operations are easier and more practical; milk is cleaner; animals have greater ease of movement and are more comfortable; and there is less injury to cows.

Four separate units are considered in the loose-housing system, each of which has its particular requirements. These units are: The bedded space, the feeding space, the paved barn lot, and the milking plant. A bedded area of 60 square feet per cow seems adequate when cows are not fed on this area. Feeding tests showed that providing hay or hay and silage in the bedded area, using it as a holding area for the cows while they are waiting outside the milking parlor, or keeping cows confined in the barn, all tend to encourage trampling of the bedded area, with the result that excessive amounts of bedding are needed and cows get dirty. In the cooperative research projects means of meeting func-

[2] Cooperating agencies in this project are the Illinois, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, Ohio, and Wisconsin stations, the Bureau of Plant Industry, Soils, and Agricultural Engineering, and the Bureau of Agricultural Economics, U. S. Department of Agriculture.

tional requirements are being developed that will tend to overcome some of the most serious objections to the system.

A wind-protected paved lot of 100 square feet or more per cow that is kept clean is essential and works well. Trials indicate that the one-time-a-day feeding of hay in a shed along the hay-storage structures is a good arrangement, and that one daily feeding of silage by truck, carrier, cart, or tractor-mounted manure fork, either under roof or in the paved lot, simplifies labor.

Milking parlors

The milking plant unit includes the milk house and milking room or "parlor." Studies with this unit show that elevated milking stalls make better milking possible, and have increased the number of cows a man can milk without fatigue from stooping and squatting. The Missouri station has developed a floor-level milking parlor with attached milk house. The size is flexible, and the lay-out is simple, convenient, and moderate in cost.

Various designs of elevated stalls have been studied. The Wisconsin station has a laboratory set up for studying different stall arrangements, and improving equipment design and the relationship of stall arrangement to type of milking machine.

Milk from loose-housing systems acceptable

Numerous industries, including barn-equipment manufacturers, milking-machine manufacturers, and prefabricated building manufacturers, are cooperating with some of the stations in various phases of research dealing with improvement of the four-unit, loose-housing arrangements. Several fluid-milk markets are now accepting milk from loose-housing systems, including such major market areas as Chicago, New York City, Milwaukee, and St. Louis. Virginia became the first eastern State to include a section on loose-housing systems in its milk regulations when they were revised this year. Before the State changed its milk ordinance, the experiment station compared the milk from cows milked in a stanchion barn with a standard-type milking machine; from cows housed in a loafing barn, and milked in a stanchion barn with a standard-type machine; from cows housed in a tie-stall barn, and milked with a combine-type milker in a milking parlor; and from cows housed in a loafing barn, and milked with a combine milker in a milking parlor. The milking parlor method gave lower total bacterial counts than milking with the standard-type milking machine. Very little difference was found in the milk from cows housed in the stanchion barn and that from cows housed in a loafing barn and milked in a stanchion barn. Leading farm papers have cooperated in presenting various phases of the project developments to the public.

Loose-housing-type barns popular among cooperators

An estimated 1,500 dairy farmers in the North Central, Northeastern, and Eastern Central States have established and are successfully operating loose-housing systems. They are enthusiastic about the research work they have found available and the planning ideas that make their application to farm conditions productive. They report costs for remodeling old barns into loafing barns to range from the amount they received for their used stanchions to as much as $300 per

cow. This lay-out includes all equipment, under contract prices current in the past year. This represents a substantial saving in original investment over the stanchion-type dairy barn lay-out.

Loose-housing systems with the resultant lower housing cost and larger dairy herds may help to keep up dairy farm incomes by increasing milk output, as milk prices ease or adjust to lower levels. They also offer a parallel advance in over-all efficiency of chore operations comparable, if not equal, to the advancement of over-all efficiency obtained through present-day mechanization in the growing of field crops.

Briefly, the advantages of loose-housing over stall-barn housing are: Construction cost is lower; it is more flexible for use and provides for fluctuation in herd size; it reduces injuries to cows; and it saves labor. The principal disadvantage is that it necessitates extra bedding for the cows. The increased cost for bedding in a properly planned loose-housing system in which no feeding is done on the bedded area is about 50 percent. This extra cost requirement for bedding may be offset by the well-preserved manure in the bedded area of the loose-housing barn.

The warm, insulated loose-housing barn has no apparent advantages over a cold uninsulated one except that calves kept in it make slightly better gains. The disadvantages noted by investigators are that insulated barns require a little more labor, the manure pack is soggy, there is a pronounced odor, and it is stuffy even when extra bedding is used.

Some of the disadvantages of the loose-housing system which showed up in earlier years have been eliminated or reduced. Moreover, some apparent discrepancies have been proved to be caused by differences in the herds.

The final answers to all the problems in this newly devised system of economic dairy production remain to be determined by future research. The cooperative approach to this research, now being effectively pursued, may give us these answers much earlier than could be reasonably expected under individual research attacks.

Loose-run housing in the Western States

In a Western regional project, which includes the Idaho, Utah, Oregon, and Washington experiment stations, the research is not so far along nor the results so conclusive, as in the North Central projects. Nevertheless, the following preliminary reports on trends are of interest.

In feeding trials carried on by both the Idaho and the Utah stations in the 1948-49 season, during one of the most severe winters on record, Holstein cows kept in open-shed barns consumed slightly more feed than those in the stanchion-type barns. In Idaho the total digestible nutrients (T.D.N.) consumed by the open-shed herd were 9 percent higher than those by the cows kept in the stanchion barn. In Utah the T.D.N. intake was 2.7 percent higher for the cows kept in sheds. There was no significant difference in milk production between the two groups of cows at the Utah station but at the Idaho station the cows kept in the open shed produced 11 percent more milk. Records kept by the Idaho station indicated that 15 percent less time was required to care for cows in the open shed than for those kept in a conventional dairy barn.

Calves kept in open sheds

For two winters the Washington station compared open sheds with conventional housing for dairy calves. The analyses completed so far show that the total digestible nutrients required per pound of gain are higher for calves housed in the open shed. Because of very low temperatures in January the condition of the calves housed in the open sheds was poorer than that of the other group. Two calves housed in sheds had the tips of their ears frozen off, while some 3-day-old calves suffered no frostbite. Calves housed in an open shed ate more than twice as much hay as those kept in a conventional calf barn during the first three months of life. No final conclusions can be reached until these trials have been carried on further and an appraisal made of all the data. It is of interest to note that Idaho reports numerous visits to the station by dairymen, 4-H Clubs, G. I. trainees, and Future Farmers of America boys, to study the results of the dairy herd housing experiments.

Improvement of existing type barns

The North Central regional project just discussed also includes studies to improve present barn types. The early barns were built for the most part of unmatched lumber and there was adequate and often too much air movement in them all the time. Newly developed building materials and new construction methods have tended to solve the problem of air movement within the structure.

The Wisconsin station is studying the bank barn, a common side-hill type of dairy barn in areas of rolling topography. Its studies include determination of temperature and humidity characteristics, a comparison of actual light intensity in bank barns and above-ground barns, a comparison of the effectiveness of artificial light and daylight in bank barns, and a comparison of odor characteristics in the two types of barns. Moisture removal is a major problem in the environmental control inside animal shelters. Moisture problems vary with climatic conditions, and therefore require solution on a local basis. The purpose of the bank-barn-type study is to find out what steps are necessary to insure suitable standards of milk quality where such barns are used. The report on this project, although not final, indicates that good lighting and good ventilation will go a long way toward offsetting any criticism of bank barns.

New development in barn ventilation

Barn ventilation for stanchion barns is under study by the Iowa station which reports investigations on the development of a heat exchanger. This device uses heat from exhaust air and water vapor to temper cold incoming air used for ventilation. In two barns with different kinds of previously unsolved ventilation problems, the heat exchanger has succeeded in maintaining safe relative humidities. With the heat exchanger cold air moves along one side of a sheet metal surface and warm air along the other side. The incoming cold air absorbs heat and is warmed so it does not create an objectionable draft on the livestock. The exhaust air is cooled and the heat of vaporization of much of the water vapor is saved by the condensing of this moisture on the cold surface of the metal. The experimental models of the heat exchanger are now being tested for practical use. They may solve the problem of barn moisture and temperature control.

Good results from any type of ventilation system are not assured unless the barn is adequately insulated and the addition of storm windows is advisable in rigorous climates. When the walls are warm and tight with intakes and outlets properly spaced, air movement can be thermostatically controlled.

Production efficiency studies

Four stations, Michigan, Illinois, Kansas, and Missouri, are engaged in projects dealing with the production efficiency in farm buildings. The Michigan station reports that time and travel studies have been made on 30 dairy farms. As a result of these studies, they suggest the following changes in the older dairy barns:

1. Locate the milk house and feed storage as near the center of the barn as possible. Provide cross alley through center of stanchion section of barn where there are 12 or more cow stalls on a side.
2. Locate hay chute over feed alleys and bedding chutes over litter alley.
3. Provide more calf and maternity pens, roughly, 1 maternity pen for 8 or 10 cows.
4. Sweep-in type of manger is most practical.

It should be appreciated that these recommendations have been developed through limited sampling of the complete problem. Proof of them will depend, of course, upon well-organized and integrated experimentation to reveal their merits.

Modernization programs have shown the farmer the value of the use of feed carts, litter carriers, and, most recently, gutter cleaners and silo-emptying devices. Great savings in the time required for doing routine chores have been effected through the use of these simple devices. Within the short space of 2 years great strides have been made toward the establishment of a few of the functional requirements which must be taken into consideration in the design of adequate dairy barns as well as in their management aspects. It is recognized that costs often appear too excessive to incorporate many of these innovations, but it is reasonable to assume that when all of the unknowns have been ascertained a proper adjustment through individual evaluation can be arrived at so that the American farmer can have the most economic structure for the job at hand.

Dairy nutrition

The agricultural experiment stations must constantly reappraise the value of dairy feeds in the light of new discoveries. For example, a dozen or more stations have tried to develop so-called milk substitutes for dairy calves with only moderate success. Recently, however, research workers in the Department and other groups reported that the newly discovered "animal protein factor," is essential for the normal growth of young animals. Grain feeds are almost devoid of this vitamin, but milk and certain animal tissues are relatively rich sources of animal protein factor. The term "relative" should be emphasized.

Station research on B_{12}, an important constituent of the animal protein factor, has in the past year been confined to work with B_{12} concentrates rather than with the pure substance which is costly. A large drug house, for example, used a ton of beef liver to isolate

1/6000 of an ounce of the crystalline vitamin. Because of its importance in the nutrition of young animals many experiment stations are anxious to obtain a few crystals of vitamin B_{12} so they may start rechecking critical experiments on the nutritive requirements of the calf and other species of farm animals.

Calves and vitamins

As a result of some recent experimental work the New York (Cornell) and Pennsylvania stations have made some worthwhile suggestions on what not to feed the calf. So-called calf starters must be low in fiber. Beet pulp, for instance, gave very poor results even when finely ground. The most successful mixtures were high in either non-fat-milk solids (dried-skim milk) or dried whey. They also contained compounds high in vitamins A, D, and B-complex and a mineral mixture including "trace" minerals. Although the Virginia and Louisiana stations both mention dehydrated sweetpotatoes as an excellent source of carotene (the precursor of vitamin A), no station has reported on the possibility of including sweetpotato meal as a source of vitamin A and energy in the ration of very young calves. Cornell workers find that young Holstein calves will grow normally (but without gaining any reserves) on 6 milligrams of carotene daily per 100 pounds of liveweight, but that Guernsey calves require 10 milligrams daily. Apparently Guernsey calves are less efficient than Holstein calves (or Jerseys, according to the Oklahoma station) in converting carotene to vitamin A.

Several groups have been studying other phases of the vitamin problem as it relates to calf nutrition. Iowa station scientists found two reasons why they feel carotene and vitamin A in colostrum appear to be more readily utilized by the calf than in commercial vitamin concentrates. In colostrum, carotene and vitamin A are dispersed in infinitely fine "particles." By homogenizing a fat-soluble vitamin concentrate into skim milk, it was possible to secure more efficient adsorption of the vitamin by the calf. A new chemical emulsifying agent proved even more efficient than the homogenizer in dispersing the fat-soluble vitamin in the milk. As a result of these findings, water-soluble concentrates of vitamins A and D are now being placed on the market.

The second reason these scientists give for securing better utilization of the carotene and vitamin A in colostrum relates to the method of feeding. Research showed that when the calf nurses the cow most of the milk bypasses the fore stomachs and goes directly to the fourth compartment, called the adomasum. When a nipple pail is used to mimic nature's plan, the milk also bypasses the fore stomachs. This method of bypassing the more or less inactive stomach compartments (rumen, reticulum, and omasum) also increased the utilization of the vitamin concentrate by the calf. The feeding of vitamins emulsified in milk and fed from nipple pails was compared with the common practice of feeding vitamin concentrates in capsule form.

Carotene is thought to be of little value to the calf except as it is transformed into vitamin A. Because plants contain only carotene (not vitamin A) it is extremely important to know just where this transformation takes place. Pending further and final confirmation the New York (Cornell) station has obtained very good evidence that the intestinal wall is the principal site for this conversion process.

Feeding very young calves

Under natural conditions the supply of vitamins occurring in the colostrum is soon supplemented by the vitamins of rapidly growing spring grass. Recent work tends to emphasize the desirability of following nature's plan as closely as possible in raising calves. In experiments at the Ohio station all of the calves that were allowed pasture after 4 days of age had much higher blood levels and liver storage of carotenoids and vitamin A during the first 6 weeks after birth than the calves kept in the barn. It is concluded that good pasture grass can be utilized by very young calves as an effective means of meeting their vitamin needs and as an economical source of other nutrients.

The Illinois station has reported that many dairymen lose 10 to 20 percent of their calves before they are 6 months of age. Some of the reasons are quite apparent to these workers. In an effort to have cows freshen throughout the year it is necessary to raise most calves on milk (pail-fed), hay, and grain. This means less sanitary conditions as well as an unnatural diet. Even the amount of whole milk has been drastically reduced in most instances. Some calves do not even receive the colostrum from their dams. Although prepartum milking (before calving) was begun in an effort to reduce the shock of calving, recent evidence from the [Connecticut] Storrs station indicates that colostrum is of greater importance to the calf than is prepartum milking to the cow.

The Iowa station found that young calves grew reasonably well when hydrogenated soybean oil was substituted for milk fat in their diet. However, the calves fed butter oil appeared much thriftier. The calves fed the filled milks scoured more readily than those on whole milk. In these experiments both groups of calves were fed vitamin concentrates. The North Carolina station has found that hydrogenated cottonseed oil is also a reasonably good substitute for milk fat for calves, provided the oil is homogenized with skim milk before it is fed.

Calves do not become true ruminants until a characteristic flora and fauna has developed in the rumen. In order to hasten this process the Ohio station fed young calves cud material from older animals. In this way they were able to "seed" the rumen at a slightly earlier age than normal. Although bacteria perform many useful functions in the rumen (synthesize certain vitamins, help free the digestible nutrients, digest certain woody materials, and synthesize simple organic compounds into food nutrients), the calves fed the cud material grew no more rapidly than the control lot up to 71 days of age. This does not mean that their body reserves were the same.

A year ago the Iowa station workers reported that raw soybeans or soybean oil depressed the carotene content of the blood but that soybean oil meal had no bad effect. This year the Maryland station obtained a decrease in both plasma carotene and plasma vitamin A after feeding a ration containing 30 percent raw soybeans. The soybeans reduced carotene values irrespective of whether the carotene occurred naturally in the plant or was added to the ration as a carotene concentrate.

Calf losses can be avoided

Calf losses in general are the result of disease or poor feeding and management. A study at the Illinois station covering a period of 12 years indicates that all dairy breeds are about equally hardy. This does

not mean that a Jersey calf can stand as much cold or drink as much milk as a Holstein calf, but under accepted systems of management recommended for that locality the losses were about evenly distributed between the five major dairy breeds.

Some farmers have added sulfonamide compounds to the rations fed very young calves. To test the soundness of this practice the New Hampshire station has set up a well-controlled experiment. In preliminary experiments it was found that sulfathaladine, when used as a prophylactic and fed with hay to dairy heifers, tended to lower the digestibility of the nitrogen and energy-producing nutrients in the feed.

Almost every year we are forced to revise our estimate of the nutritional value of one or more dairy feeds. For many years timothy hay was discouraged as a feed for growing dairy heifers. Now the Illinois station reports that in an experiment with 15 Holstein heifers the ration containing 70 percent timothy hay and 30 percent grain by weight produced the largest rate of gain and required the least amount of total digestible nutrients per pound of gain. This ration was compared with a ration of clover hay, silage, and grain. The quality of the hay was not stated, although the results suggest that the hay was cut and cured without much loss of color or leaves.

Effects of fasting

In a study by the Maryland station on the feeding and management of cattle during the dry and freshening period, it has been observed that fatty livers, so often observed in cows suffering from ketosis, can be duplicated by merely fasting an animal, and that fatty livers therefore are not necessarily a fundamental part of the syndrome observed in ketosis. Further, it is possible, by maintaining a low plane of nutrition following parturition, to reproduce the blood picture observed in cows with ketosis, but not the symptoms. Primarily as a result of this study the practice of feeding cows more liberally prior to and following parturition is receiving rather general acceptance by dairymen.

Vitamin E will not solve breeding troubles

One of the most interesting studies concluded this year with mature dairy cattle was that on vitamin E. In 1931 two foreign workers reported that of 17 cows that failed to breed 13 dropped live calves after treatment with wheat-germ oil, a feed high in vitamin E. Until 1935 no American experiment station challenged this statement although many commercial feed manufacturers used such information to promote the sale of wheat-germ oil as a cure for sterility in dairy cattle. In 1935 the Iowa station reported that four generations of goats had reproduced normally on a vitamin-E-deficient ration. But dairy farmers are usually skeptical of results obtained with goats. Now the Minnesota station, after 10 years of research, has proof that neither wheat-germ oil nor any other feed rich in vitamin E will solve breeding troubles common to dairy cows. The Minnesota station found that the organs of reproduction developed normally in cattle of both sexes fed vitamin-E-poor rations throughout their lives. There were no abortions, and fetal membranes were expelled in the usual time. Sterility continues to be a serious source of loss to dairymen in this country, but much valuable time and money can be saved by disregarding wheat-germ oil as a

therapeutic for this condition. The Minnesota workers did find a few cases of heart abnormality among their experimental animals but they emphasize that E-free rations are never fed under practical farm conditions.

Among other important findings resulting from this study are the following: Feeds do not readily lose their vitamin E content through long periods of storage nor do feeds naturally low in vitamin E adversely affect the utilization of carotene and vitamin A by the cow; the milk was normal except for a lower vitamin E content. The experimental animals had normal blood levels of ascorbic acid, hemoglobin, calcium, phosphorus, and cholesterol. Most of the vitamin E extracted by the cow from a low E ration is concentrated in the liver. The vitamin E content of the blood, milk, and feces of the experimental cows was much lower than normal.

Hard-to-settle cows

The Wisconsin station reports that, according to its research and contrary to popular opinion, the difficulty with hard-to-settle cows is more often inability to carry the embryo to term than failure to conceive. A herd of about 100 hard-to-settle cows with no apparent physical defects was brought together, bred artificially to the same sires with which they had failed to conceive in 4 to 13 consecutive artificial inseminations, and studied intensively. About 60 percent of the cows were found to have settled on the first test insemination. Within 5 weeks after insemination two-thirds of the settled cows had "lost" their calves or the embryos were too abnormal to live. Many of the settled cows even came back into heat on schedule as though they had not been pregnant. Much more work will be needed to find out the more important reasons why such cows fail to carry the embryos to full term.

Increasing viability of bull semen

This year 12 experiment stations reported on problems concerned with artificial breeding of dairy cattle. Most of these experiments had to do with increasing the viability of the semen. The New Jersey, Pennsylvania, New York (Cornell), and Louisiana stations tried adding sulfanilamide, sulfasuxidine, penicillin, and streptomycin (separately and in combination) to the semen to counteract destruction of spermatozoa by hostile micro-organisms. Although semen so treated generally gave higher rates of conception than untreated semen, there was no unanimity of opinion as to which treatment was preferable.

The New York (Cornell) station mentioned the desirability of not stirring semen samples any more than necessary. They explain the harmful effect of stirring was caused by the incorporation of more air and subsequent transformation by the spermatozoa of the oxygen from the air into hydrogen peroxide. By adding to the semen an enzyme catalase which destroys hydrogen peroxide, the New York (Cornell) and Illinois station workers were able to improve the motility of the spermatozoa. These workers therefore recommend that receptacles for shipping semen should always contain as small amount of air as possible. In the light of the great interest now being shown in vitamin B_{12}, it should be mentioned that the New York (Cornell) station reported that animal protein (skim-milk powder), when fed to breeding bulls,

was no more effective in improving the quantity or the quality of the semen than was vegetable protein (corn-gluten feed and soybean oil meal).

Dehydrated sweetpotatoes as cattle feed

Southern dairymen are much interested in dehydrated sweetpotatoes for dairy cattle because of the very high calorie yield per acre compared with corn in the South. Previous reports have indicated what southern experiment stations are doing to evaluate this valuable product. Most recent reports are from the Virginia and Louisiana stations. According to work at the Virginia station, this feed is palatable and high in carotene and digestible carbohydrate but low in protein and fat. In two trials dehydrated sweetpotatoes were 91.4 and 94.8 percent as valuable as ground yellow corn in the dairy ration. On the basis of the yields in some areas the value of sweetpotatoes as a stock feed may justify growing them specifically for cattle feeding.

Ensiling grasses and legumes

Successful methods of ensiling many grasses and legumes have been developed in recent years, thus reducing the dependence on silage corn. Studies at the New Jersey station show that the acid content of any silage must be low enough to prevent fermentation. Materials containing arabinose, glucose, sucrose, fructose, and xylose are satisfactory for silage preservation. Excellent silage was produced using 80 to 140 pounds of molasses per ton, the pH of the silage being between 4.4 and 4.3.

The use of xylose as a preservative for silage raises the question as to the utilization of wood molasses or its decomposition products by ruminants. Although wood molasses lacks palatability the New Hampshire station found that the metabolizable energy in wood and cane molasses are comparable.

The Oregon station reports that milk production was approximately the same whether the cows received alfalfa silage preserved with cane molasses or wood-sugar molasses. The silage made with wood-sugar molasses seemed more palatable. These, along with earlier findings with growing dairy heifers, indicate that this product may become an inexpensive source of energy.

Feeds and fat tests

Since milk is usually sold by the farmer on the basis of its fat content, dairymen are constantly concerned with their butterfat test. Breeding is the most potent method of altering the butterfat content of milk. However, Oregon station workers report that soybeans have a tendency to raise the fat content of the milk to a greater degree than soybean oil meal. Because the amount of milk did not change, the increase in total pounds of butterfat produced was small.

For many years it has been known that cod-liver oil when fed in large amounts to milking cows decreases the fat content of the milk. Not long ago a commercial laboratory reported that tocopherols increased the fat test without depressing milk production. This appeared to be a very interesting lead. However, carefully conducted trials at the New York (Cornell) and Minnesota stations show that tocopherols when fed to dairy cows have no appreciable effect on the fat of the milk.

The source of fat in the dairy ration is a real problem in Hawaii. The station there has also investigated the relation between feed fat and the test of the milk produced. On the basis of the amount and test of the milk produced by cows on a double-reversal trial, a ration containing 3.7 percent fat (ether extract) was compared with one containing 1 percent fat. The higher fat ration was superior and had the further advantage of slowing down the rate of production decline with advancing lactation.

Minerals

Projects concerned with the role of minerals in the dairy ration have received less attention this year than formerly. But the Michigan station is continuing to study the physiological role of cobalt, and the New Hampshire station has been concerned with tolerance levels. The latter station found that "the levels of cobalt generally added to concentrate rations by feed manufacturers and those generally recommended for inclusion in mineral mixtures appear to afford a wide margin of safety."

Pastures and forage crops for dairy cattle

The dairy cow is better able to utilize forage crops than any other farm animal. She not only can consume large quantities of roughages but can convert them very efficiently into milk. Consequently, dairy farmers are becoming more and more conscious of the value of good pastures and improved hay crops. Information is being sought on better pasture management, more fertilizer is being used on grasslands, and demand has increased for seed of improved strains and varieties of legumes and grasses. Grassland farming not only produces the required animal nutrients more cheaply and in greater abundance but provides a more efficient farming system and gives greater protection from erosion than cultivated crops. Furthermore, the need for supplemental feeds, largely from cultivated row crops and cereal crops, is greatly reduced. In a successful grassland farming system, small grain crops are grown as a means of renewing hay and pastureland every 3 or 4 years and to furnish grain, straw, and supplemental grazing. Thus, high-protein concentrates are the only feeds that need to be purchased.

Good pastures cut costs for other feeds

The value of good pastures for producing cows has been proved at several of the experiment stations. Research has been undertaken by some experiment stations and more is needed on the development and maintenance of meadows in relation to good farm management practices. Farmers need practical scientific information on the extent to which grazing and forage production may be substituted for feed grains to get more economical milk production on increased production of soil-conserving crops, and on reduction of soil-depleting crops.

Recent work at the Ohio station showed that cows grazing on a legume meadow produced as much milk as a similar group on the same pasture plus hay. In the same experiment it was determined that only 21 pounds of grain per hundredweight of 4-percent milk were necessary for maximum production.

Winter grazing

Alabama and other southern stations have developed all-year pasture programs and even in the northern States the grazing season has been markedly extended. A pasture system has been developed at the Missouri station which provides good grazing nearly the year round. In brief, the system consists of (1) permanent pasture in late spring, early summer, and winter; (2) lespedeza pasture in midsummer and late summer; and (3) rye, barley, or other grain throughout the entire fall or early spring. The permanent pasture, consisting of various grass and legume mixtures, is grazed rather heavily until early July and is then suspended to permit growth for winter pasture.

At the Tennessee station, Jersey cows grazing Balbo rye and crimson clover from December to April produced 12 percent more milk and consumed 32 percent less legume hay than a control group that was barn fed. Another group of cows kept on winter pasture day and night produced milk more efficiently than other groups pastured 3 to 5 hours a day or barn fed. All groups received alfalfa hay, silage, and grain. The group on pasture from 3 to 5 hours a day produced 21 percent more milk, consumed 37 percent less hay, and returned 31 cents more per day above feed costs than the barn-fed lot. It is concluded from this experiment that dairy cows may be pastured for all but about 20 days in winter at a net saving of about $40 per cow for the winter season.

Comparative values of winter forage

In a winter-grazing experiment for dairy cattle, carried on by the North Mississippi Branch station at Holly Springs, comparative values of winter forage were studied. Land equally fertilized and treated was divided into six 6-acre plots. Three different grazing combinations were seeded on these small pastures and each trial was repeated twice. Cattle were placed on these plots on November 28 and were grazed until May 1.

The milk from all groups was sold as Grade-A milk. The profit, per cow, reported by the Mississippi station, was as follows: Dry feed, no grazing, $92.12; oats and Balbo rye, $111.75; oats and crimson clover, $122.02; and oats and Italian ryegrass, $158.58.

On an acre basis, the profit was as follows: Oats and crimson clover, no grain added, $61.01; oats and Balbo rye, oats added, $67.37; and oats and Italian ryegrass, oats added, $92.29.

Winter pastures yield more Vitamin A

At the Georgia station, considerable research has been done on improvement of permanent pastures and development of supplementary and winter pastures. It has been determined that the vitamin A content of milk from cows on winter pasture is double that from cows on dry-lot feeding. A 3-year grazing trial with dairy cows revealed that fertilized winter pasture returned a net profit of $67.16 per acre more than unfertilized pasture.

Some forages low in tocopherol content

Chemical studies show that factors other than high yield and high milk production may have to be considered. For example, the New York (Cornell) station has determined that when the tocopherol con-

tent of milk fat is high enough it will prevent or will tend to prevent oxidized flavor in milk. This oxidized flavor appeared in the milk during the feeding of Ladino clover, which is low in tocopherol, but when the cows were transferred to birdsfoot trefoil pasture, which is high in this substance, there was a noted improvement in the keeping quality of the milk. It is possible, however, to offset the low tocopherol content of certain forages by the addition of tocopherol to feed supplements.

Rough permanent pasture studies at Storrs

The 17 variously managed 2-acre clover pastures of the [Connecticut] Storrs station were grazed quantitatively by yearling Holstein heifers in 1948 as for many previous years. The four best pastures had practically the same yields in 1948 and had received the following treatments for at least 10 years: (1) Lime and "complete" fertilizer (nitrogen applied annually); (2) complete fertilizer (N annually); (3) lime, superphosphate, and potash annually; and (4) lime, superphosphate, and potash every third year. Many of the lime and superphosphate plots, either with or without potash, produced about twice as much pasturage as the unfertilized check plot. The poorest fertilized pasture was the one which had received no phosphorus since the initial application in 1924.

The three plots with lime and superphosphate plus more potash than the others had the most native white clover in June 1948. The three averaged 32 percent of the area occupied by clover, whereas the unfertilized check had 0.5 percent, and the two complete fertilizer pastures each had 10 percent. Because of its short growth native white clover influenced yields chiefly by supplying nitrogen for the grasses through its root nodules.

Although rough permanent pastures should not be depended upon for a uniform amount of grazing throughout the season, they do produce the cheapest feed for livestock. In 1948, a season with one of the driest August-October periods on record, the 30 acres of regularly fertilized pasture in the Storrs trials averaged 1,280 pounds of digestible nutrients per acre, which in grain at $80 per ton would cost over $70; or even in hay, at $30 per ton, of nearly $40. As the most expensive treatment given any of the plots does not exceed a cost of $10 annually, it is evident that untilled, unseeded, rough, low-valued land when left in permanent pasture can be used to produce low-cost feed.

The problem of good pasture for dairy cows is particularly important in the intermountain country and studies recently completed at the Utah station show what can be done. Workers at the station report that fertilization with manure (5.25 tons) and treble superphosphate (87 pounds) increased the time of grazing from 183 to 257 cow-days; whereas on a fertile soil with an improved pasture mixture 325 cow-days of grazing were obtained. The data also show the economic value of devoting good irrigated land to improved pasture by making it a third more productive. Many dairymen in the State have adopted the recommendations of the station.

More productive summer pastures

Until recent years pastures were available only during the late spring and summer months and it was necessary to feed large quantities of hay, silage, and grain during a major part of the year. This picture has

changed with the increased emphasis on grassland farming and the development of improved varieties of grasses and legumes, which provide better mixtures for permanent pastures and furnish supplemental grazing through all four seasons. Kentucky bluegrass formerly was the basis for most permanent pastures in all sections of the country and it is still important in certain areas. During the summer months, however, bluegrass pastures become more or less dormant and grazing must be reduced or stopped altogether. For this reason more productive grasses, such as orchard grass and bromegrass, are replacing bluegrass in permanent and supplementary pastures.

Studies by the Ohio station showed that the annual forage yield of bluegrass-Ladino clover pasture was the equivalent of 2.3 tons of hay per acre, while bromegrass-Ladino clover pasture yielded the equivalent of 3.2 tons of hay per acre. However, the protein content of bluegrass was 30 percent greater than bromegrass. The protein content of bromegrass pasture dropped markedly during July and August as a result of undergrazing during the spring months. This emphasizes the fact that the newer pasture mixtures cannot be utilized on the same basis as the older bluegrass pastures.

In a test of supplementary pastures at the Virginia station, four pastures were studied: (1) Alfalfa and orchard grass, (2) alfalfa and bromegrass, (3) Korean lespedeza and orchard grass, and (4) pure Ladino clover. The first two pastures provided 172 days of grazing, the lespedeza-orchard grass pasture 148 days, and the Ladino clover 131 days. It was noted that dairy cows on pure Ladino clover lost excessive amounts of body weight. The carrying capacity of these pastures was calculated as 1.85 cows per acre for the alfalfa-grass pastures, 0.64 cows per acre for the lespedeza-grass pasture, and 0.93 cows per acre for Ladino clover.

By placing a value of $5 per hundredweight on 4-percent milk, the four pastures produced, respectively, $196, $157, $135, and $134 of milk per acre.

Legumes improve marsh lands soil

The Wisconsin station, in seeking ways to improve Kentucky bluegrass pastures on marsh borderland soils, found that a mixture of Ladino clover, smooth bromegrass, and alfalfa gave yields as high as 4½ tons per acre, three times that of well-fertilized bluegrass. This study indicates that legumes with grasses increase production on these soils more than commercial nitrogen fertilizer applied to grass alone.

Ladino strains resistant to winterkilling on trial

In other pasture-management research, the Wisconsin station reports that legume-grass (alfalfa-brome or alfalfa-Ladino-brome) pastures are proving the most generally satisfactory for that State. Properly managed, they can produce many times the forage yielded by the old standard Kentucky bluegrass, and they will maintain production during the middle of the summer when bluegrass dries up. On the basis of nutrients, a good Wisconsin pasture of alfalfa and bromegrass will give a better yield than most cash crops, and at a much lower cost. Most important management practices consist of rotational grazing with avoidance of close grazing, renovation when necessary, and adequate soil treatments. In southern Wisconsin, Ladino is proving in most ways

an ideal pasture legume except for some liability to winterkilling. Some strains have proved much more resistant to winterkilling than others in preliminary tests. The other pasture components, alfalfa and bromegrass, are likewise being tested extensively, with indications that they may be improved greatly. An unusual approach to Wisconsin, Missouri, and other pasture research is the studying of the effects of the component crops on each other as well as of their individual growth and production. For example, after a few years, bromegrass has a marked effect on the stand of alfalfa growing with it.

Preservation and curing of forage crops

During recent years considerable interest has developed in the preservation of forage crops, in the form of hay and silage, for use as a supplement to pastures and, in many cases during the winter, as the sole source of roughage. It is known that the nutritive value of field-cured hay is lower (except under ideal climatic conditions) than barn-dried hay or silage. Rapid advancement has been made in drying methods and equipment and in ensiling legume and grass crops.

Recent work by the West Virginia station has given information on the old question of the value of hay stored in stacks. These careful studies revealed a difference in grades of hay. Mow hay had a better color and also contained about three-fourths more carotene than hay stored in stacks. However, on the basis of actual feeding tests, where the two hays were fed on the equal dry-matter basis, there was no difference between the stack and mow hay cut and cured at the same time in the same way. These workers conclude that hay, when placed in well-made stacks, can be stored for one season without appreciably greater losses than when stored in a mow, especially if the same feeding conditions are followed so that excessive waste is prevented.

The Vermont station has found that mow-cured hay using auxiliary heat has more carotene and 85 percent as much vitamin D as sun-cured hay. These results indicate that rickets should not be a problem in calves fed this kind of hay.

Barn-curing, using forced atmospheric air, makes possible the storage of hay with a moisture content of 40 to 45 percent. At the Virginia station it was found that barn-cured hay had 22.8 percent protein as compared with 19.7 percent in field-cured hay. Furthermore, the carotene content of barn-cured hay was 34.8 micrograms per gram and only 19.6 micrograms per gram for field-cured hay.

Extensive experiments have shown that the mow-hay curing system, originally designed for other parts of the country, was not satisfactory at the Wisconsin station. This method, however, offers particular advantages in Wisconsin because of frequently unfavorable weather during the haying season. A central duct with a slatted floor instead of laterals was found to work much better than other systems in the deeper mows usually found in that State, especially with chopped hay. The experiments have also shown that a simple blower is not satisfactory because of the cool, highly humid nights in Wisconsin. Auxiliary heat apparently must be used, and many studies have been made to determine the most satisfactory source of heat and power.

Most promising of the types of equipment tried out is an electrically operated oil furnace and blower unit. That combination reduces danger of fire to a minimum, helps make excellent quality hay, and can also

be used for drying corn, grain, and farm-grown lumber. Installations using waste heat of an internal-combustion engine to drive the blower have also proved satisfactory, but present a greater fire hazard. In either case operating costs may range from $2 to as little as $1 per ton of hay at present prices. A most important result is that mow drying often improves the feeding value of the hay.

Studies at the New Hampshire station indicate that early-cut timothy hay is lower in digestible protein but may be a better source of energy than good legume hay for dairy cattle. Early-cut timothy hay furnishes up to three times as much digestible protein and one and one-fourth times as much metabolizable energy as late-cut timothy.

Disease-resistant forage through plant breeding

Much of the increased production of pastures and hay crops can be attributed to the efforts of plant breeders. High-yielding disease-resistant strains have been developed by many of the stations and workers are constantly seeking to improve existing varieties and to breed new strains and varieties with more desirable characteristics.

A good example of the type of plant-breeding work that is proving to be of great value in a dairy section is that carried on by the Vermont station. Since 1942 extensive work has been done on the improvement of Ladino clover, zig-zag clover, and the trefoils. Doubling the chromosomes of ordinary Ladino clover resulted in larger and more vigorous plants. An important factor of this new strain is that it will not cross back to the ordinary Ladino; thus the desirable characteristics of the new strain cannot be lost. These studies have not yet progressed to the point where their results are utilized by growers, but field tests are being made to determine the behavior of the new plants under field conditions and in competition with other plants.

Veterinary research and dairy farming

Research in many phases of veterinary medicine is playing an ever more important role in economical milk production. Veterinary science deals with the ills that beset the cow family from birth to death. Significantly, it also involves the safety and health of those consuming dairy products and of those intimately associated with the daily care and management of cattle. Two examples of station veterinary research of particular interest to dairy farming in the past year are given in this article. Other phases of veterinary research affecting all livestock are given further on in this report.

Anaplasmosis

Certain diseases such as mastitis and brucellosis (Bang's disease) are under continuous study by a number of the experiment stations and because of their wide human interest they are the subject of articles appearing in the popular press. One disease, anaplasmosis, not so widely known by the general public yet receiving intensive study at some experiment stations, is reviewed here because it represents an economic hurdle that must be coped with by dairymen in various sections of the country. It also illustrates station attack on such problems.

Anaplasmosis is a serious infectious and transmissible disease of cattle. It not only causes heavy death losses but also severe losses re-

sulting from decreased production of milk and meat. It has been reported in 27 States and is continuously prevalent in the southern portions of the United States. However, it is not infrequently reported in other parts of the country. It appears, in fact, to be slowly spreading to new areas and is becoming established in the Middle West and in some of the more northern States.

An estimated loss of $4,000,000 to $6,000,000 annually to dairy and beef cattle owners is accredited to anaplasmosis. Originally the disease was considered to be a part of the piroplasmosis or tick fever complex, but in 1910 it was found to be a specific disease caused by what is almost universally accepted to be the protozoan, *Anaplasma marginale*, a small round or ovoid body observed in the red blood cells.

Animals that have recovered from anaplasmosis become "carriers" for an indefinite period. A carrier can be innocently shipped to a clean area and set up new infections where means of transmission are present. The protozoan is transmitted in nature by several species of flies and ticks. Man is also responsible for spreading infection by instruments used in various surgical operations, vaccination, and other handling when small amounts of infected blood are carried to susceptible animals.

Aricyl and Quinoline Diphosphate Show Promise.—As yet researchers have been unable to artificially cultivate the causative agent of anaplasmosis nor have they been successful in developing a completely satisfactory treatment or diagnostic agent. However, the search goes on. In the past year the Oklahoma station[3] reported that aricyl, an arsenical when used alone in treating acute anaplasmosis, resulted in 71 percent of recoveries. When it was administered with quinoline diphosphate to five cows, while in late stages of the disease, the combined treatment resulted in 100-percent recoveries. The station reports that possibly quinoline diphosphate alone may be responsible for the noticeable recovery in these five animals, rather than the combined effects of the two drugs. The studies are continuing.

Antimalarial Drugs.—The Oklahoma station also reports favorable results in combating anaplasmosis with Paludrine, an antimalarial drug. On the other hand, workers at the Kansas station are not satisfied with results of their tests with this drug on acute anaplasmosis. Texas is trying antimalarial drugs on experimental cases of anaplasmosis with apparently favorable results in the few animals tested, but these experiments are still in the promising-lead stage. At this time the same may be said for the studies going on at the Florida and Louisiana stations. In other words, research workers have reached no conclusions as to specific results that may be had through antimalarial drugs.

As previously pointed out, no drug has yet proved to be completely satisfactory. Even those drugs that appear to have some value in aiding the affected animal to withstand and recover from an attack of the disease do not destroy its cause. Such animals remain carriers of the infection just as those that recover from an attack without drug treatment.

Research to Control Anaplasmosis Carriers.—The principal carriers of anaplasmosis are ticks and horseflies. Everywhere blood-sucking insects are potential vectors. The Oklahoma station [3] has found that a mixture of DDT or methoxychlor and sufficient benzene

[3]Oklahoma Veterinary Research Institute and the Oklahoma Agricultural Experiment Station.

hexachloride to kill full-fed ticks provided good control of the ticks but did not affect the horseflies. However, appreciable amounts of these insecticides appeared in the milk and meat of the treated animals which is undesirable from the standpoint of the consumer. Effective tick-control materials that will not appear in the milk or tissues of sprayed animals are needed. Also more economical and longer lasting horsefly repellents are needed, even though much progress has been made. Piperonyl butoxide-pyrethrum spray is relatively nontoxic and provides fair protection for 2 or 3 days. However, its cost will reduce its usefulness, although it may be practical in some instances on dairy cattle or against flies that are spreading anaplasmosis or anthrax.

At present we do not have means of detecting cattle that are carrier animals. Department workers and the California station are studying use of the complement-fixation blood test which appears to be very promising. Through this test they are able apparently to detect 90 to 95 percent of the carrier animals. Extensive field and laboratory trials may prove that this test is a great step toward eventual control of anaplasmosis.

Immunization Possibilities Being Studied.—In spite of the large amount of work that has been done on anaplasmosis the exact way in which the *Anaplasma marginale* protozoan causes illness in the host animal is still unknown. The Nevada and Oklahoma [3] stations have undertaken studies in which they are attempting to cultivate the protozoan artificially. If successful this procedure could very possibly lend itself to the preparation of diagnostic agents for detecting the disease and also the development of immunizing agents that will not make carriers of the animals so treated.

Anaplasmosis research is an expensive procedure mainly because cattle must be used as experimental animals. Small laboratory animals cannot be used because they have not proved to be susceptible to the disease.

In recognition of the seriousness of the disease and its economic importance to both the dairy and beef cattle industry, the Department and the State agricultural experiment stations in Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, and Virginia have drawn up plans for a coordinated research program. As funds become available for the project, each agency and station will concentrate on a segment of the problem in the hope of finding an eventual control measure for the disease.

Brucellosis

The 1948 report (page 115) contained articles on important research conducted at the stations on brucellosis. Because of the danger to man through association with animals infected with brucellosis, research at many of the stations continues along lines of unsolved problems.

Brucellosis Ring Test.—The brucellosis ring test, which originated in Germany and has been utilized extensively in Denmark and modified even more recently by the Michigan and Minnesota stations, has been conducted on approximately 30,000 composite samples of herd milk and cream. Thus far the test has proved quite accurate. It gives much the same results as the agglutination test except that milk is used in place of blood. A negative test on a sample of herd milk indi-

cates that all cows in milk are free of brucellosis. If the sample is positive, individual milk samples will have to be obtained. Failure to disclose diseased animals will occur in those herds where reactors are not in milk production at the time of the test.

On the basis of field experience to date, it is estimated that with three veterinarians, each with a part-time helper, to collect the cream and milk samples and a veterinarian and technician to supervise and test the samples in a trailer laboratory, the ring testing could be completed in an average county in one week. Thus, application of the test on a semiannual basis in counties under the brucellosis control program for the area may prove to be a very effective and inexpensive way of keeping the disease at very low levels in the intervals between reaccreditation serum agglutination tests.

Whey Agglutination Test. — At the California station it is believed that the whey agglutination test is an important aid in differentiating vaccinated from infected animals in a given group of reactors to the blood-serum agglutination test. The need for such a diagnostic aid has been brought about by widespread use of *Brucella abortus* Strain 19 vaccine which has somewhat clouded interpretation of the regular tests because of persistence of agglutination titers for a variable period following vaccination.

Better fly control around dairy barns

Flies, including the housefly which is notorious for its disease-carrying activities, are most unwelcome around dairy barns. Health officers insist that these germ carriers be reduced to a minimum where milk is produced and handled. The cows themselves are also annoyed by these pests and are restless, especially during milking if the flies are numerous.

During World War II American scientists found that DDT, an insecticide discovered in Europe, could be applied in various concentrations to kill a great variety of insects. Although both experiment station and Department entomologists cautioned from time to time that all phases of the problem had not been studied, DDT became widely used on dairy farms, both as a barn spray and as a spray for cattle. It was used for the latter purpose because it brought comfort to the animals. During the past year the Food and Drug Administration of the Federal Security Agency announced that research had shown that animals in contact with DDT or which ate DDT in feed or on forage carried the material over into their bodies and into the milk, with possible harmful effect to human beings. Consequently, DDT was generally discarded as a fly spray on dairy cows and in dairy barns. Although there is no prohibition to its use on dairy farms where there is no danger of contaminating human foods, research in the past year has shown a further limitation that may affect the use of DDT around dairy buildings.

DDT-resistant flies

Before DDT became available for fly control around dairy barns, the battle with flies was a constant and strenuous one. Many devices and frequent sprayings were used. With the advent of DDT, applied as a residual spray to the walls and ceiling, flies almost disappeared in dairy barns and this was accomplished for an entire fly season with two or

three spray applications. This fly-free period lasted 2 or 3 years wherever DDT was widely used. Its effectiveness still continues in some places, but in many others the swarms of flies have returned. This recurrence has been reported by scientific workers in various sections of the country and from abroad. The situation has prompted research by the experiment stations, first, to learn why flies have developed resistance, and secondly, what suitable substitutes for DDT can be used to control them.

Early in the spring of 1948 numerous reports were received by the California station that DDT residual sprays were not resulting in satisfactory fly control in southern California, particularly in dairies. Numerous theories to explain these failures in control were advanced, such as (1) current DDT production was inferior to that of previous years, (2) stocks of DDT had deteriorated in storage, (3) DDT residual-spray treatments were being improperly applied or used at ineffective dosages, (4) 1948 was an exceptionally favorable year for fly breeding, and (5) flies had developed resistance to DDT.

A preliminary investigation showed that, regardless of the cause, DDT residual spraying was in most cases ineffective for fly control in southern California areas.

The California station in its investigation of the cause of poor fly control by DDT found that the amount of actual DDT in the 50-percent wettable DDT sold for fly control varied only a fraction of 1 percent for 1946, 1947, and 1948. A test of these DDT's against a "normal" strain of housefly showed them all to be of equal killing strength, but using the same form and concentrations of DDT on different strains of houseflies gave astonishing results. The resistance of the Bellflower strain of houseflies to DDT was 333 times; that of the San Jose strain, 22 times; the Ontario strain, 14 times; the Riverside strain, 13 times; and the Hyman strain, 4 times that of the laboratory strain of flies.

These differences in resistance appear to be inherited. For example, the Bellflower strain had maintained its resistance to DDT for over 15 generations, all bred in the laboratory and completely free from contact with DDT. Moreover, the differences in resistance were not caused by the size of the flies, as females of the Bellflower strain averaged 18.8 milligrams per fly and the laboratory strain 21.2 milligrams. Female flies of the other strains ranged between these two in weight.

Research to find DDT substitutes

In order to make rapid progress in providing adequate substitutes for DDT in fly control field studies were begun by the California station in the summer of 1948 with a number of synthetic insecticides. Barn spraying was carried out in the standard manner. A high-pressure spray rig was used and the walls were sprayed until the runoff point was reached. In all cases, applications were made when the animals were out of the barn.

DDT trials in which DDT was applied as a 50-percent wettable powder at 40 pounds per 100 gallons of spray (approximately 2.5 percent), showed that thorough spraying with this material in some cases eliminated the flies for a few days but generally provided no significant residual action. In some localities no effect on the fly popula-

tion could be observed following the DDT applications. Such occurrences coincided with the presence of highly resistant fly strains.

Benzene hexachloride and methoxychlor

In comparative tests of fly resistance to DDT and four other insecticides, benzene hexachloride[4] appeared to be the most satisfactory of those tested. Used at the rate of 17 pounds of a 12-percent gamma-isomer wettable powder in 100 gallons of spray (approximately 0.25 percent gamma isomer), BHC accomplished effective control for 3 weeks to 1 month during the hottest summer weather and up to 2 months during the cooler fall weather.

BHC should not be used in milk rooms or around open milk containers because of the possibility of imparting a disagreeable odor to the milk. For this same reason, as well as because its animal toxicity has not been completely evaluated, it should not be sprayed directly on the animals.

Methoxychlor gave from 1 week to 1 month of fly control in some situations. In others, however, where it proved less effective the flies were definitely resistant to it. In areas where flies are extremely resistant to DDT, methoxychlor is likely to result in poor fly control. However, as it is only about one-fortieth as toxic as DDT to warm-blooded animals it is less hazardous to use. Toxaphene and chlordane gave good initial clean-up of fly infestations. Their residual effectiveness, however, was often of short duration.

Some results have indicated that DDT-resistant flies may become resistant to BHC in a comparatively short time. Where this proves to be the case it may be necessary to return to sanitary measures, repellent materials, and space sprays for fly control around dairy barns.

The Oklahoma station had established spray schedules and concentrations of DDT for fly control in barns by the fall of 1947, but early in the 1948 season it was apparent that previously successful measures were not controlling houseflies. Consequently higher concentrations, more applications, new chemicals, and residue removal were studied intensively by the station workers. Their conclusions are that (1) in some areas houseflies develop resistance to DDT; (2) substitution of other chlorinated hydrocarbons provide control; methoxychlor, BHC, chlordane, and toxaphene in the order mentioned are effective; (3) stablefly and blowfly control in barns requires much more extensive spraying than housefly control and the results are not so complete; (4) sanitation is still very essential and must be stressed; (5) dust removal by washing will increase the insecticidal activity of residual deposits; and (6) maximum housefly populations now appear 1 to 2 months later than before the widespread use of chlorinated hydrocarbons.

Further research in this field is being continued at both the California and Oklahoma stations, since experience over a number of seasons will be necessary before a complete evaluation of the various materials can be made.

[4] Benzene hexachloride, usually referred to as BHC, is a mixture of isomers of which the gamma isomer is by far the most effective insecticide and has only a slight odor. Grades of BHC of low gamma content must be used at relatively high concentrations of total BHC to obtain sufficient gamma isomer for good insecticidal results. The low gamma BHC is unrefined and has a penetrating and persistent odor that may be absorbed by food and impart a flavor that is objectionable to most people. Recently the pure (99 percent or more) gamma isomer of BHC has become commercially available for insecticidal use and has been named Lindane.

Dairy economy

Ten years of change in Vermont

In the Northeastern States dairying is a major type of farming. For this reason experiment stations in this region have conducted numerous surveys to understand better why certain farmers prospered and others failed, why some communities preferred to sell their milk cooperatively, while others patronized private distributors, or why one area sold to one city and another area to another. These studies have not only furnished the answer to many practical questions but they have also provided a basis for further research. A few examples will help the reader to appreciate better the amount of data gathered, summarized, and interpreted by the experiment stations.

The changes that are taking place in dairy farm organization and operations in many parts of the country are indicated in a report of the Vermont station on 10 years of dairy farming in the State. The dairy farms of the State are increasing in size, production, and efficiency of operation. Yields of all crops, other than corn, were larger at the end of the period. Increases of 18 percent in the number of cows and 23 percent in the production per cow accounted for the fact that 37 percent more milk was sold at the end than at the beginning of the period. Change in production per cow as a result of a 61-percent increase in the amount of grain fed per cow was the result of a more favorable milk-feed ratio. Between 1935 and 1939, changes in production tended to lag about a year behind changes in the milk-feed ratio.

At the end of the 10-year period near the end of World War II, 38 percent more milk was sold for each man working than at the beginning. This increase in labor efficiency was a result of increases in size of business and higher rates of production and made possible a slight decrease in the labor supply. Only three factors—age of operator, type of market, and debt load—were found to have much effect on the changes noted. The oldest operators made the smallest changes in size of farm and were able to increase production chiefly by feeding more grain. The middle-aged farmers made the greatest increase in production and efficiency. The younger farmers made the greatest increases in size of business.

The form in which farmers marketed their dairy products changed considerably. Farmers who shifted from the sale of cream to fluid milk made the greatest increases in size of business and in production. Those who sold the most fluid milk throughout the period made the greatest advances in efficiency, size of farm, and production. Farmers who sold cream throughout the period had small herds, low production per cow, and made poor use of labor. The size of the farmer's debt per cow did not affect the changes made as greatly as did his age or the market to which he sold his milk. The farmers with the largest debt had the smallest herds at the beginning. However, they operated the most acres at both ends of the period and made the greatest increases in acreage and size of herd.

Earnings on Oregon dairy farms

In order to advise farmers on management factors conducive to successful dairy farm operation in Oregon, the Oregon station analyzed the earnings made on seven typical dairy farms in the State. The aver-

age size was 114 acres, of which 40 acres were in tillable pasture and 21 acres in harvested crops. The estimated value of the land and buildings was $18,717. Average inventory value of livestock, machinery, equipment, crops, and supplies was $10,227. Total capital averaged $28,944 per farm or $255 per acre. Average total cash receipts were $11,559 and inventory increase was $1,744, making total receipts $13,303. Total expenses were $11,206, leaving a net farm income of $2,097. Average total farm investment was $28,944. Labor income varied from a loss of $2,392 to a gain of $2,729, the average being $939. The farms having the greatest returns against purchased feed and labor costs had the highest labor incomes. High labor income was attributable to more efficient labor, higher milk production, and more efficient feeding, particularly of purchased feeds. Good improved pastures were also a contributing factor. Dairymen increased their labor income by the maintenance of adequate pastures and haying meadows and the production of as much home-grown feed as crop adaptation and available land would permit.

Changes in dairy farm income

In a study made by the New Hampshire station of the changes that occurred in the incomes of 44 wholesale dairy farms in the State, over the period 1939-45, inclusive, receipts were shown to have climbed rather steadily from $2,717 in 1939 to $5,890 in 1945. Expenditures increased from $2,487 in 1939 to $4,351 in 1945. Net income increased from $230 in 1939 to $1,539 in 1945. These figures do not include the value of farm products used in home consumption, which varied from $526 in 1939 to an estimated $750 in 1945.

Seasonality of milk production

A compilation of available information on the seasonality of milk production was issued by the Maine station for the Northeastern region.[5] It pointed to uneven seasonal production as one of the most pressing problems confronting the fluid milk industry. In contrast to wide seasonal swings in milk production, the consumption of fluid milk remained relatively constant throughout the year. Heavy production in the months from April to July was compared with the relative scarcity of production in the months of September to December. Serious as this situation was before World War II, it was made graver by the demand for all-out production to help win the war. In the Boston and New York milksheds, daily deliveries per producer during November and December from prewar to 1946 averaged only 58 pounds for every 100 pounds delivered during May and June.

Some factors responsible for uneven milk production and distribution are management, weather, feed consumption, month of calving, dairy merit (efficiency of milk production), disease, and insects. The longer-time shift toward more uneven production has been attributed to the lack of sufficient seasonal variation in milk prices under wartime conditions and controls. During the war period the Office of Price Administration froze dairy prices and practically eliminated seasonal price changes as well as the selling margin between Class I and Class II

[5] Cooperating Northeastern stations include those of the States of Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, Virginia, and West Virginia.

milk. Subsidy payments provided some seasonal adjustments in returns to dairymen but perhaps were not as effective as a corresponding seasonal change in milk prices paid directly to the farmers.

The combined effect of all these forces results in low production in the Northeastern States (Connecticut is a good example) in the months from October through April, and relatively high production from May through September.

Since cows may be bred in any month of the year, the dairyman has an opportunity to even out production by breeding at the right time. The greater the number of cows milked from September to December the more nearly the supply is evened up for the year. Given two herds each with spring-fresh cows, the one with high dairy merit would be expected to have higher milk production relative to the total than the one with low dairy merit. The herd with high dairy merit will be producing more milk in the latter part of the lactation period than a herd of low producers. The supply of milk may also be increased during months of scarce production by feeding the herd better in the late summer, fall, and winter months. High temperatures and extremely low temperatures are unfavorable, with a temperature range of 40° to 50° F. the most favorable to milk production.

Major costs are feed and labor. The farmer, considering an adjustment in production, will base his decision on anticipated costs and returns under his own particular situation. Uniform milk production throughout the year in the Northeastern States, according to the report, seems to be associated with more milk per cow, higher total production per man unit, lower cost of production particularly in terms of feed and labor, and a higher net income. Farmers tend to respond best to prices, such as lower price in April, May, and June, and reciprocally higher price in the scarce-production months from October to December.

The report shows that on the whole, even year-round production has proved to be more profitable than uncontrolled seasonal imbalance.

Dairyman's chores

Chores make up more than half of the total yearly work on dairy farms but many experiment station investigations are showing how work can be done in less time and with less help. For example, the Michigan station found that chore time during the winter averaged about 6 hours a day, the labor with the dairy cows making up 86 percent of the total. The time with the cows was distributed as follows: Milking, 48 percent of total; cleaning mangers and feeding cows, 16; caring for utensils, 13; cleaning stables and bedding cows, 13; caring for milk, 6; and getting cows in and out of barn, 4 percent.

It was proved that reducing the milking time alone can make a great contribution in cutting labor costs. Efficient, properly organized milking can hold the time down to 3 minutes per cow. The station showed the value of three possible ways of solving this problem, namely, by improving the stable layout, the equipment, and the work methods.

Cost of keeping a bull

In comparison with the services of the artificial breeding associations the Pennsylvania station found that the cost of keeping a bull varies widely, depending on the feeding, breeding, and management

practices of the dairymen. The annual net cost of keeping a bull ranged from $182 for purebred bulls kept in a special corral to $125 for grade bulls that were permitted to run with the cows. On individual farms the range in cost was considerably greater. In general, feed accounted for slightly more than one-half of the total cost, and labor was next in importance, representing almost 30 percent of the total.

The cost of artificial breeding service was $5.20 per cow. This was considerably cheaper than the average cost (per cow) of keeping a bull, which was $9.59 for purebred herds and $9.86 for grade herds. The higher costs for grade herds are due to their smaller size. Dairymen following the practice of keeping a bull for most of their herd while using artificial breeding on the remainder had the highest total breeding costs, averaging $12.46 per cow.

Cost of producing milk

In a study of the cost of producing milk as a guide to more economical production, the Vermont station found that costs ranged from $2.62 to $10 per hundredweight, with an average of $4.78. Over a 20-year period the amount of grain fed was influenced by the ratio between cost of the grain and selling price of the milk. In 1926, 26 pounds of concentrates were fed for each 100 pounds of milk produced. Six years later, when prices were much lower, 23 pounds of grain were fed, whereas in 1946, 38 pounds were fed. Costs were influenced by such factors as labor efficiency and size of business. As capital investment increases per man, the quantity of milk produced increases and operating costs go down. High production per cow decreases costs materially and a close second in effecting greater efficiency is evenness of output the year around. Factors not affecting costs materially are cropland per animal unit and the butterfat test of the herd.

The Ohio station found that the labor required per cow was 72 percent greater and cost per 100 pounds of milk averaged about $1 higher for herds that were milked by hand than where milking machines were used. The herds milked by hand averaged 10 cows as compared with 16 in herds where mechanical milkers were used.

Cooperative milk plants

In a study of cooperative milk plants the North Carolina station found that they have become an important part of the State's dairy industry. About 500 farmers now sell their milk through cooperative associations. Cooperative sales in 1948 accounted for approximately 12 percent of the cash farm income from dairy products.

All dairy co-ops in the State are incorporated as capital stock associations under the North Carolina Cooperative Act. They have membership contracts through which members agree to deliver and sell to the co-op all the milk above home requirements and to comply with all local health requirements in milk production; whereas the co-op agrees to pay for milk on the basis of grade and quality and to keep records of volumes and equities for producers. Milk collecting routes vary in length from 1 to 75 miles. As a general rule, milk trucks are owned and controlled by individual producers. Hauling charges vary from 15 to 35 cents per 100 pounds and are paid by the producer.

Farmers selling through co-ops received 63.7 cents out of every dollar that the consumer spent for milk. Processing costs account for 18.9

cents; selling expenses, 13; and administrative and general expense, 4.4 cents. Processing expense for all associations ranged from $1.51 to $2.57 per 100 pounds of milk, with an average of $1.97. Distributing expense per 100 pounds ranged from 63 cents to $1.60 and averaged $1.24. Administrative and general expense ranged from 32 to 52 cents per 100 pounds and averaged 42 cents.

DAIRY PRODUCTS RESEARCH

Research in dairy technology conducted at the State experiment stations is annually making valuable contributions of great importance to producers and consumers. This research is aimed at providing the consuming public with assurance of a steady flow of wholesome milk, butter, cheese, ice cream, and other nutritious foods made from milk. Some of this phase of dairy research is closely integrated with that of dairy cattle management. Other phases deal with dairy chemistry and bacteriology and the handling of milk from the cow to the table in accordance with sanitary rules for the protection of the consumer, whereas other studies seek to improve methods of manufacture. Dairy technologists are constantly searching for new methods to improve dairy manufacture with an eye on nutritive properties, taste, and other consumer appeal.

Undesirable flavors of milk

Experiment stations are carrying on numerous research studies whereby undesirable flavors are being identified and suggestions found for their elimination.

"Cowy" flavor

The Pennsylvania station reports that cowy flavor in milk is not the result of contamination of the milk. It occurs when the cow's system is harboring unusual amounts of acetone compounds or ketone bodies. When milk exhibits this peculiar flavor, Pennsylvania dairy scientists suggest that samples from each cow be tested with the well-known nitroprusside test and the milk from the offending cow or cows be discarded.

Rancidity

Rancidity in milk is caused by the action of a fat-splitting enzyme present in the milk at the time it is secreted. Although this enzyme attacks the fat molecule, California station workers have shown that it is actually present in freshly secreted milk in the nonfat portion. When milk is cooled the lipase enzyme becomes adsorbed to the surface of the fat globule and starts to work. The only way to prevent the splitting of the fat by the enzyme and development of a rancid flavor is to pasteurize the milk.

Off-flavors caused by overheating

Improper pasteurization (overheating) also creates off-flavors. The Pennsylvania station has been attempting to isolate the minor organic compounds which form when skim milk is heated to 122° C. for 60 minutes. The compounds thus far identified include (1) acids of the aliphatic series, such as acetic and butyric, (2) carbonyl acids, (3) sulfur-containing acids (nonamino), (4) mono- and dicarbonyl compounds,

and (5) furan compounds. The specific identity of these compounds is being studied in an effort to improve the quality of pasteurized milk products. Maryland station workers, using different techniques, have also observed the presence of reduced sulfur groups from the liberation of hydrogen sulfide gas. They have tried to determine the relationship of these sulfur compounds to small amounts of ammonia which are also liberated when milk is heated momentarily to 95°.

Ohio station workers have discovered that a positive nitroprusside test, previously mentioned in connection with cowy milk, is very closely correlated with the degree of cooked flavor in pasteurized milk. This test is also helpful in determining the soft-curd characteristics of highly heated milk.

Improved manufacture

Increased consumption of milk and milk products has been linked closely to improved methods in handling and processing. Less than a hundred years ago, the only means of obtaining fresh milk in New York City was by keeping cows inside the city limits. Such practices as pasteurization, refrigeration, and reconstitution of dried milk are relatively recent. Neither the dairy processing industry nor the agricultural research stations are taking for granted that final perfection has been reached. They are constantly at work at improving existing methods and developing new ones in order that more people may benefit from the use of milk, and a corresponding increased use of milk and milk products be brought about.

Improved methods for homogenizing milk

Homogenized milk is constantly increasing in favor with the consuming public. Anticipating this trend, the Michigan station has been developing methods of producing the best quality product possible. It reports that during the past year station dairy workers have been able to correct what is known in the trade as "rough" or "spotty" homogenized milk. In bottling machines homogenized milk sometimes becomes mixed with a certain amount of foam. Because milk solids tend to concentrate at film surfaces, the collapse of these air cells results in a flaky concentration of denatured milk solids at the surface. Predisposing factors are large particles of milk fat that accumulate in the milk as it is bottled. The Michigan station workers found a solution of this problem in keeping the bottling machine full so that no foam can enter the bottle, and also in making sure that there are no particles of butterfat present in the milk by the complete dismantling and thorough cleaning of the pipes after bottling nonhomogenized products.

Dairy technologists at the Washington station have been able to measure the efficiency of homogenization of milk by means of a photoelectric colorimeter. Although this instrument is not available to small milk-processing plants, because of its cost and the need of a technician for its operation, the method offers larger plants an important aid in determining the efficiency of their homogenization procedure.

Stabilizers for chocolate milk

The North Carolina station has run a number of tests comparing stabilizers, cocoa powders, and milk ingredients used in the production of chocolate milk. It studied six stabilizers used to prevent the coarser

chocolate particles from settling and to insure a smoother product. A desirable flavor and appearance were obtained when the milk with 0.0555 percent Irish moss was brought to 120° F. before adding the various ingredients. With sodium alginate, best results were obtained when 0.25 percent of the stabilizer was mixed with three to four times its weight of sugar and added to milk at 160°.

Reconstitution of condensed and dried milk

Consumer demand for milk in condensed or dry form largely depends upon the naturalness of the reconstituted product and the cost. Washington station workers found that a more satisfactory whole-milk powder was produced when the milk was separated and the resulting cream and skim milk were preheated at different temperatures before combining and drying.

Dried buttermilk in bread

Several experiment stations have been interested in building up a greater consumer demand for dry milk in bread. The Minnesota station reports that dried buttermilk produced a larger loaf than when nonfat dry-milk solids were used. According to the Washington station the nonfat solids when dried at temperatures which produced maximum whey protein denaturation resulted in greatest loaf volume. In drying milk, not only is the time and temperature important, but these workers found that more heat was required to destroy the whey proteins in solids samples that were less dilute to start with.

The California station prepared breads containing different amounts of nonfat dry-milk solids. They found that boys 8 to 16 years old voluntarily ate 14.5 percent more bread when 14 percent of the flour was replaced with dry skim-milk powder. Although dried buttermilk and dried skim milk added to the quality of fresh bread, the Minnesota station found that these breads would not keep well for prolonged periods at high temperatures.

Spray drier improvement

The Minnesota station has patented a device for improving the standard type of spray drier and has entered into a licensing arrangement with a commercial concern for its manufacture. This device is based upon evidence that concurrent air and milk flow are preferable to counter-current air and milk flow in spray drying. Data have also been secured indicating that reducing substances originating from the serum protein fraction of the milk are of major importance in the antioxygen effect of heat treatment in preventing the bad flavor that results from oxygen being present.

Natural flavor in ice cream preferred over imitations

Many station dairy technologists are engaged in research directed at the improvement of ice cream and reduced cost of production. The Michigan station conducted a study to determine whether the public prefers a pure flavor or an imitation flavor in ice cream. Its research included five types of vanilla extract (natural and artificial) and five types of strawberry concentrate or extract. In every case the judges were overwhelmingly in favor of the ice cream flavored with the pure extract or concentrate. The report emphasizes that ice cream manu-

facturers who hope to stay in the business will probably find using the higher grade extract to be of economic advantage. This practice will also permit the manufacturer to attract business by advertising that his ice cream contains no artificial flavoring materials.

Dried whey for ice cream and sherbets improves flavor

The Missouri station has shown that ice cream and sherbets that receive as much as 90 percent of their serum solids from dehydrated, spray-process whey possess a desirable flavor, body, texture, and melt-down. Above 70 percent of whey solids, the product does not stand up well. This same station, as the result of recent experimental work, is recommending "cultured" ice cream made with 3-percent dehydrated culture. Not only do many people like the distinctive flavor of cultured ice cream but they note that the body of the cream becomes more smooth and mellow. The texture becomes proportionately closer and the resistance to melting greater. Replacing one-third of the cane or beet sugar with corn sugar made the ice cream smoother and gave it a more desirable melt-down.

Dairy technologists at the North Carolina and Georgia stations have been concerned with ice-crystal formation and air-cell size in ice cream. One important finding is that shrinkage in ice cream is caused by collapse of the air cells when the ice cream is pressed down with a paddle or scoop.

Cultures for processing fancy cheeses

Cheese has come in for extensive station research. Work is under way especially to learn more about making the popular fancy cheeses. The Iowa station has developed a procedure for the manufacture of blue cheese (Roquefort type) from pasteurized homogenized milk which gives the desired open texture, abundant mold growth, good body, and adequate flavor. The dominance of *Penicillium roqueforti* in blue-veined cheese was found by the Washington station to be caused by the ability of this organism to grow profusely in high concentrations of carbon dioxide and not by its ability to grow in low-oxygen concentrations. Several species of molds, e.g., *P. expansum* and *Oospora lactis*, grow more readily in low-oxygen concentrations than does *P. roqueforti*.

At other stations work is under way to learn what the difference is chemically between a mild cheese and a sharp cheese. As many as 17 different nitrogeneous compounds have been isolated from well-ripened cheese. Only small amounts of tryptophan in cured cheese are reported. This differs sharply from the results of a commercial laboratory where a close correlation between tryptophan and the desired high flavor was found. The Wisconsin station reported that a small quantity of diacetyl contributed to the typical flavor of Cheddar cheese.

During the ripening period brick cheese should have a characteristic slimy appearance. The Wisconsin station has discovered that this slime as well as reduced acidity is produced indirectly as a byproduct of yeast growth. This favors the growth of *Bacterium linens*, the typical microorganism associated with brick cheese, which is unable to grow in an acid environment. In addition, the yeast supplies *B. linens* with some essential growth factor or factors.

The Indiana station developed a satisfactory method for the manufacture of a miniature Swiss-type cheese. Success of the method depends

upon the use of pure cultures of bacteria, a carefully controlled ripening temperature, and frequent turning during the curing process. The Pennsylvania station has been able to speed up the curing process for Romano cheese used in grated or shredded form. Partial homogenization and pasteurization enter into the process.

Dried and semisolid whey products offer possibilities

The Idaho station has been trying to find additional uses for the dissolved protein left in cheese whey, which is often wasted. It was found that whey protein when dried could be used successfully as a substitute for eggs in certain bakery products. As much as 2 percent whey protein could also be homogenized into cream used for manufacture of cream cheese. The resulting cream cheese had a better, more spreadable body and texture than the cheese made without it.

In preliminary feeding trials at the Nebraska station on the nutritional requirements of pigs in dry lot, in which pigs in both lots were given the same basal ration, one lot receiving additions of a hand-fed, partially dried whey product, the whey-fed pigs made an average daily gain of 0.2 pound higher than the control lot receiving none of this material, and also made more efficient gains. The whey product fed at 24.6 pounds replaced 50.5 pounds of shelled corn and 20.7 pounds of mixed protein supplement per 100 pounds of gain at a saving in cost.

Handling cream to make good butter

Quality in butter depends, among other things, upon the source of the cream or butterfat. For this reason many scientists have begun carefully rechecking the physical and chemical properties of this milk fat when secreted and also after it has been processed and stored. Earlier research proved that fat in cream continues to change in physical state for some time after it has been brought to any specific temperature. Applying this information the California station was able to show why cream churns more quickly and with less loss if it has been cold until the fat has become stabilized and then brought to churning temperature, as compared with cream quickly cooled from the temperature of pasteurization and then churned. The New York (Cornell) station recommends that creamerymen, when making cultured cream, use pasteurization temperatures near 165° F. for 30 minutes for smoothest, driest, and most viscous butter. They even recommend adding a little rennet if local restrictions do not prevent its use.

Cream and butter held in storage at very low temperatures sometimes tend to develop a metallic to fishy flavor. At the same time vitamins A and E decrease. According to the Iowa station, however, there is no correlation between oxidation of the fat and loss of vitamin A potency. Scientists at the New York (Cornell) station note that nordihydroguaiaretic acid (sometimes referred to as NDGA) prevents the development of objectionable oxidized flavors at subzero temperatures for periods as long as 247 days. This antioxidant also prevented the destruction of vitamins A and E. Only 0.005 percent nordihydroguaiaretic acid was required to produce this remarkable stabilizing effect. The cost is small.

The New York (Cornell) station was able to lengthen the storage life of cream pasteurized at 143° to 170° F. from 4 to 6 months, depending

upon the presence of vitamin C, to at least 2 years by pasteurizing at 160° to 170°, churning, and storing the butter or the pure milk fat.

The dairy department at the Minnesota station sought a more reliable sediment test for cream delivered to the cream station. A solution of sodium hexametaphosphate (1½ to 2 pounds in 10 gallons of water) was found to be a satisfactory diluting fluid for high-acid and for high-butterfat cream in making the sediment test.

Effect of feed on fatty acids in milk

Certain fatty acids in milk impart a disagreeable or undesirable flavor. Feed has more influence on the percentage of such fatty acids in milk fat than upon the total fat content of the milk. Dairy technologists at the Iowa station have found that the variations in content of the highly unsaturated fatty acids encountered in summer butter are primarily the result of (1) feeding cows pasture instead of dry feed and (2) stage of lactation. Changes in temperature appear to be of considerably less importance. At the beginning of the lactation period milk fat contains a maximum amount of the highly disagreeable low-melting-point unsaturated fats, provided the cows are fed the same ration throughout the year. These unsaturated fats in the milk tend to decrease for about 5 months and then slowly increase again. The feed which the cow receives will modify these typical changes more than will changes in temperature.

Immunizing effect of bacteriophage

A bacteriophage is a type of ultramicroscopic agent like a virus which produces a transmissible destructible effect on bacteria. The Indiana station discovered that the acid-producing ability of cultures of *Streptococcus lactis*, which causes milk to sour, is not greatly influenced by contamination with bacteriophage after the first few transfers. In fact many strains of *S. lactis* became so resistant to the bacteriophage contaminant that the bacteriophage actually died out after several transfers. The viability of the bacteria was increased or the resistance of the bacteriophage was decreased with increasing temperature up to 37° C. This immunizing effect of a bacteriophage toward its host may have considerable importance where rigid sanitary conditions are not or cannot be maintained.

The Iowa station has classified 66 strains of bacteriophage common to *Streptococcus lactis*. It found that the rates of bacteriophage increases and *S. lactis* multiplication were greatest at 32° C., for the five combinations tested. In many cases mass cell destruction took place in less than 5 hours, but there was little or no change in degree of alkalinity. Antisera peculiar to the different strains have been prepared by injecting bacteriophage into rabbits. Many of the bacteriophage strains have also been studied by means of the electron microscope. Because bacteriophage destroys the desirable types of bacteria used in the ripening of cheese, a better understanding of how the undesirable bacteriophage can be destroyed or rendered harmless is extremely important to the dairy industry.

Germicides for use in and around dairies

Quaternary ammonium compounds are finding wide acceptance as germicides in the dairy industry. The dairyman or creameryman, how-

ever, has had no ready method of determining the effectiveness of the solution that he is using. The Massachusetts station has recently developed a semimicromethod for testing these germicides which makes it possible to accurately determine their germicidal potency. In studying this problem Massachusetts station workers discovered that a five times stronger solution of this type of material was required for 100-percent kill of germs in a very acid medium (pH 3) as in very alkaline solution (pH 10). They also found that trivalent metal positively charged ions in the wash water had 10,000 times more interfering power than monovalent ions. Trivalent ions frequently inactivated the quaternary compound under test 100 percent in concentrations of 10 parts per million. When the wash water was neutral these ions, fortunately, lost their interfering power. Since quaternary ammonium compounds are among the most useful sterilizing agents available to the dairy industry, any method of increasing their germicidal value will benefit both the producer and the consumer of dairy products.

Milking equipment and bacterial content of milk

The North Dakota station studied the bacterial content of milk drawn aseptically from supposedly normal udders. No gland was found free of organisms. The first-drawn milk was higher in bacterial count than the middle and last-drawn milk. The lowest counts were usually obtained from samples drawn about midway in the milking process. In producing low-count milk under usual farm procedure the station found that clean warm water is practically as effective as hypochlorites or quaternary ammonium compounds for washing the udder before milking and rinsing the teat cups between the milking of each cow. Quaternary compounds are more suitable for washing the udder than hypochlorites because of the greater stability of the former and because hypochlorites tend to dry or chap the teats. The South Dakota station intimates that careless handling of the milking machine by the operator may be just as important a factor in producing high bacteria count milk as the condition of the milking machine. The Michigan station has compared storing teat cup liners of the milking machine in three ways, viz., dry, in 0.5 percent lye solution, and in 200 parts per million of a quaternary ammonium compound, a cationic germicide. Dry storage proved least satisfactory. For most types of organisms the other two methods proved about equal in value.

Vermont has made an intensive study of the epithelial cells found in freshly drawn milk. After examining some 6,000 samples, the station workers are convinced that the number of cells increase with the age of the cow. There is also usually an increase in total cell count early and late in the lactation period. The cell picture is quite different in acute than in chronic mastitis. A high cell count in a sample of well-mixed milk from a young cow is proof of a serious condition.

MARKETING RESEARCH

Experiment station research is contributing with increasing thoroughness leadership in finding more efficient ways for farmers to market their products at good profits. The Research and Marketing Act has given added incentive to such research. Funds made available under this and prior acts are helping to solve problems dealing all the way

from harvesting a perishable crop with least spoilage and insurance of longer storage life to surveys among consumers on preferences for packaged or unpackaged fruits and vegetables.

Dairy marketing

Marketing is a major consideration in the determination of prices to consumers of milk and milk products. It is in the interest of both producer and consumer that marketing and distribution methods follow a pattern that is economically sound and in line with modern health and sanitary requirements. Research in dairy marketing has set such a pattern as its major objective.

Fluid milk for the Nashville market

The Tennessee station went into the seasonality of milk production and marketing of fluid milk by farmers in Rutherford County, a source of milk supply for the Nashville area. Milk production ranged from an average of 1,755 pounds per cow on one farm to 11,970 per cow on another. Net returns varied almost as much as production per cow. Each increase in production of 100 pounds of 4-percent milk per cow increased net returns by about 6 cents per hundredweight. The group of producers who made most profit apparently aimed at even seasonal production but had some slump in production during the late fall months. This group of producers had the highest receipts per hundredweight and the second lowest cost of production. In addition, milk production per cow was higher than the average for all cows. This research reveals that producers in the Nashville marketing area might well aim at increasing total milk production per cow, even at the expense of some decrease in percentage of butterfat content.

Fluid milk for the Detroit milkshed

The Michigan station analyzed cost and income records of 85 farmers in the Detroit milkshed during the 1947-48 marketing year. The herds averaged 16.5 cows, varying in size from 6 to 43 cows. Production per cow averaged 7,942 pounds, ranging from 4,941 to 11,447 pounds per cow for the year. Butterfat production averaged 301 pounds and ranged from 190 to 404 pounds per cow in individual herds. The feed of the average cow per year was about 1½ tons of concentrates, 2 tons of hay, 2 tons of silage, and 153 days of pasture. Labor averaged 120 hours per cow, 16 hours per head of young stock, and 80 hours per bull for the year. The cost per 100 pounds of milk averaged $4.54 and ranged from $3.34 to $8.90 in individual herds. One or more bulls were kept in 68 of the 85 herds. Net bull costs for the year averaged $196. The average cost of raising a heifer to 2 years of age approximated $228.

Fluid milk distribution in Puerto Rico

The agricultural experiment station of the University of Puerto Rico appraised the costs and practices employed in the distribution of milk in Puerto Rico. Puerto Rico has more than 500,000 cuerdas (1 cuerda equals 0.97 acre) in open, clear pasture and around 300,000 cuerdas in unimproved pasture land. The area devoted to pasture was about two-fifths of Puerto Rico's total land resources.

Average wholesale prices per quart of raw milk sold by the middlemen studied were as follows: Milk stand, 16.5 cents; producer-distributors, 17 cents; and distributors, 18.1 cents. Milk stands, producer-distributors, and distributors obtained 18.6, 19.1, and 19.8 cents, respectively, per quart of raw milk retailed. Four out of five distributors studied sold pasteurized milk only. It was sold for 20.7 cents a quart at wholesale and for 21.1 cents a quart at retail.

Costs to the middlemen studied of distributing fresh milk were low. Operating costs of producer-distributors and milk stands per quart of fresh milk sold were lower than those of distributors. The higher net operating profit per quart sold obtained by producer-distributors and milk stands as compared to distributors, was largely due to the former's greater efficiency in marketing the product.

Livestock and wool marketing

Many things happen to a steer or a hog between the time it leaves the farmer's feed lot and the moment it walks through the trap door in the slaughterhouse. Livestock producers have felt for years that greater efficiency in selling meat on the hoof would accrue to their advantage. Research in livestock marketing has, therefore, obtained front-rank attention. Some of this research is likely to pay off in improved practices that the experiment stations anticipate will come out of research reported in the past year. Some examples follow:

Price differentials for slaughter hogs

A regional research report on price differentials for slaughter hogs was issued by the Iowa station for 12 out of 13 north central stations participating. Yearly and monthly differentials cover the period 1931-41 and daily differentials the period 1937-41. Hog prices were highest on the east coast and west coast, which were areas of deficit production. In the upper Mississippi Valley, hog prices were relatively low. Hog price differentials between markets tended to change from year to year, from month to month, and from day to day, when prices were uncontrolled. At a given market, price differentials between weight groups of hogs also tended to change from one period to another. Annual variations in price differentials between weight groups of hogs resulted from changes in the relative volume of hogs of different weights marketed, which was largely due to variation in the feed supply and to changes in the hog-corn price ratio.

Seasonal price differentials between some markets were fairly consistent from year to year. Seasonal changes in price differentials between weight groups of barrows and gilts were caused primarily by changes in the supplies of hogs of the different weights. Price differentials between sows and barrows and gilts were widest in July, August, and September when sows comprised a relatively large proportion of all hogs marketed. Sows generally sold to better advantage at markets in the western Corn Belt than at markets in the eastern Corn Belt. Research information of this kind will be very helpful in developing educational programs which are being expanded by the Extension Service and other educational agencies to provide farmers with an understanding about price differentials in marketing hogs.

Montana livestock auction markets

In a study of livestock auction markets, completed and reported in 1948, the Montana station found that 10 markets, well-spaced geographically throughout Montana, sold 424,460 cattle and calves in 1946. Six auction markets operated in Montana in 1941 and sold 110,798 cattle and calves compared with 470,184 cattle sold during 1947 by 12 auction markets. The largest movement to auctions was by truck. An average of 67 percent of cattle was moved by that means in 1946, compared with 28 percent by rail and 5 percent driven. The managers of all Montana auction markets or their representatives followed the practice of buying cattle and calves in the country or in other auctions and selling them in their own auctions. All operators of auctions, or their representatives, purchased cattle in their own sales rings. Principal types of buyers were ranchers, butchers, and packers, traders, feeder buyers, and packer order buyers. Charges for selling cattle varied from $1.35 per head in two auctions to $2.20 in another market. One auction charged a percentage of the selling price, which in 1946 resulted in the highest charges made by any Montana auction. Replies from 393 ranchers who returned questionnaires indicated that livestock auctions met with the general approval of Montana producers in 1946.

Marketing cattle by carcass weight and grade

In a study to determine the advantages of marketing cattle by carcass weight and grade (i.e., slaughter cattle arriving at the terminal markets) rather than by liveweight, the Minnesota station found that errors in pricing live animals range up to $125 on a 24,000-pound carload. These studies point out that details in marketing on the carcass basis include identification, weighing, and grading carcasses; making settlements to owners; and assessing condemnation losses. To operate most effectively, a carcass-selling system would probably require uniform grading by disinterested parties at the different terminal markets.

New Mexico livestock and feed rates

Livestock production is the most important agricultural enterprise in New Mexico. An important economic consideration that enters into livestock operations in the State is the matter of freight rates. In a survey of freight rates, the New Mexico station found that, although the freight rate per ton-mile is in general principle supposed to be lower for greater distances, New Mexico livestock men actually pay higher rates than producers competing with New Mexico. New Mexico lacks grain, and the rates on both grain and prepared feeds into the State are higher than those into some competing areas. Eastbound livestock rates from New Mexico points are higher than from points in Colorado and Wyoming that are equidistant from the same markets.

Back fat yardstick for measuring hog quality

Information that may revolutionize the system of marketing hogs has been obtained in a regional Research and Marketing project carried on cooperatively between 10 State experiment stations and the Department. The information obtained definitely relates the thickness of back fat on the hog to the quality of the hams, loins, shoulders, butts, bellies, and other important pork cuts. As a result future marketing practice

may put a premium on hogs marketed by the farmers who follow scientific recommendations with respect to breeding, feeding, and generally good hog management.

Graded wools sell higher

The Texas station, as its part of a regional research project in which eight States and the Department are cooperating, graded out 691,000 pounds of grease wool belonging to 59 patrons of the Sonora wool warehouse. The grading showed 50 percent of Fine staple wool, 39 percent of Fine French combing wool, and 11 percent of Fine clothing wool. The graded wools sold for an average of 80.2 cents a pound whereas the "original bag" wools averaged 75.5 cents a pound, an advantage of 4.7 cents a pound in favor of the graded wools, and a total advantage of $32,477 for the 59 lots of wool. If applied to the entire clip of Texas 12-month wool, this advantage would amount to $1,884,000.

Poultry and egg marketing

Poultry and eggs furnish one of the most valuable sources of protein in the American diet. However, a large amount of this valuable food material has been going to waste under conventional marketing practices. Marketing research, as reported by the experiment stations in the past year, is helping to stop unnecessary waste through better handling and care of poultry meat and eggs from the farm to the consumer's table.

Changes in egg quality during marketing

An economic loss of over $32,000,000, measured in terms of eggs produced on United States farms during 1948, was disclosed in research completed on egg quality changes during marketing in the North Central States. The project was carried on cooperatively by 12 State experiment stations in the North Central States, Kentucky, and the Department. A careful inventory was made of what happens to eggs from the point of first sale by the farmer to the central assembling plants from which the eggs go to stores for consumers.

Many good eggs lost their top quality by being held too long at country points for grading. Eggs held 1 day or less in the summer changed only 7.8 points in quality, whereas eggs held 2 days or longer changed 17.6 points. Eggs sold by farmers on a graded basis averaged about 70 percent A's as compared with about 60 percent A's for those sold ungraded. The information obtained from this and related projects in other regions will help save millions of dollars of losses suffered annually in the form of deterioration, spoilage, and waste, the cost of which is paid by consumers in higher egg prices and by farmers in the form of lower prices than high-quality eggs are worth on farms.

Why egg quality deteriorates

The Kentucky station found in the regional egg marketing study that between 5 and 12 percent of the eggs delivered by Kentucky farmers never reached the consumer. These losses occurred on the farm before the eggs reached the first buyer.

In the Kentucky study, 114 separate lots of eggs in four sections of the State were graded during April, August, and November of 1948.

In these months, 28 percent of all eggs were dirty or stained as they came from the farmer. In April, when quality is at its best, less than half of the eggs delivered from the farm classified as U. S. Consumer Grade A or better; 3.5 percent showed cracks and shell damage at the time of delivery; and 1 percent was not salable. In August, less than 20 percent of all producers' eggs sampled graded U. S. Consumer Grade A, or better; shell damage was 3.5 percent; and 7 percent were not salable. About 4.5 percent of the eggs were cracked or checked upon arrival at concentration points. Apparently rough handling, poor cases, and transportation caused the added 1-percent breakage. Grade changes between the time eggs were received at local stores and produce houses and their arrival at the next point in concentration were small by comparison with loss in quality on farms. Farmers are not aware of these serious losses because the practice of buying "farm run eggs" by the dozen does not recognize quality differences at the farm level; rather the price is lowered enough to pay the cost of sorting, handling, and grading. Farmers can get higher prices by improving egg quality on the farm and by marketing them according to grade.

Marketing dressed and drawn chickens

Chicken marketing in New York is secondary to egg marketing as measured by the contributions each is making to farm income. This is emphasized in a survey on the costs and returns in marketing dressed chickens reported by the New York (Cornell) station in 1948. The marketing period covered was that of July 1, 1946 to June 30, 1947. The report showed that the average return per hour of labor used by poultrymen marketing dressed chickens was $1.13. This compared with an average return for labor used in taking care of the laying flocks on farms cooperating in the project of $1.27 per hour and of 63 cents per hour for that used in rearing chicks.

Fresh chickens are marketed in New York State principally in two ways—dressed and drawn. Dressed chickens are marketed as "New York dressed," meaning that the birds are bled and picked, but not eviscerated. The loss of weight of dressed chickens is about 10 percent. In case of drawn chickens, the loss of weight is greater. In the absence of modern cooling and refrigeration equipment, the drawn birds also become more perishable. In the survey reported, slightly over one-half, or 52.5 percent of all the chickens sold, were marketed as New York dressed. The most important outlet for drawn chickens was institutions, which accounted for nearly 70 percent of the birds marketed. The dressing percentage for New York dressed marketed broilers was 88; for drawn, 65. Comparable percentages prevailed between dressed and drawn marketed birds in the fryer, roaster, fowl, and capon classes.

Fruit and vegetable marketing

Information coming out of nutritional research has made consumers conscious of the importance of fruits and vegetables in the diet. Growing fruits and vegetables on a commercial scale has been greatly aided by research. In a similar way the new approach to cooperative marketing research is netting fruit and vegetable producers important information on how to get these perishables to consumers in better condition, with less waste, and to the greater economic advantage of both

producers and consumers. Examples of such research reported in the past year follow.

Cost of packing fresh citrus fruit

The Texas station, in a study of the cost of handling Texas fresh and processed citrus fruits, during the 1946-47 season, found that packing costs increased by more than 25 percent when fruit was packed in consumer-size bags rather than bruce boxes. The variation in costs of packing in the various containers was caused chiefly by differences in the cost of the container itself, and of packing and handling. Cost of packing material represented from 45 to 50 percent of the total cost of handling fresh citrus. Oranges and tangerines involved higher labor costs than grapefruit, chiefly because the fruit is smaller and requires more time in handling and packing. Generally, oranges require about 1.5 times as long and tangerines 3 times as long to move through the packing house as is required by an equal volume of grapefruit. Packing sheds which handled 300,000 to 700,000 boxes of citrus cost 5 cents less per $1^3/_5$ bruce box of grapefruit than those that packed under 300,000 boxes.

Paperboard containers lower grapefruit marketing costs

Production of grapefruit in the United States amounts to over 63,000,000 boxes a year. Development of a new paperboard type of container to take the place of wire-bound, wooden boxes in the marketing of grapefruit, which saves producers 15 cents per box and assures that the grapefruit will reach consumers in better condition, has resulted from a cooperative regional Research and Marketing project carried on in Arizona. Comparative studies of costs of handling Desert grapefruit with field boxes and with the bulk handling system showed that there was a net saving of $23,000 per 700,000 field boxes where the bulk-handling system was used. Consumers showed a marked preference for grapefruit marketed in yellow bags rather than the red mesh bag commonly used for oranges.

Ripe peaches preferred by consumers

The Louisiana station in 1949 reported a survey of consumers made to obtain their reactions and attitudes toward the purchase of tree-ripened peaches in retail stores. With full-ripe peaches priced at 13 cents a pound and green-ripes at 10 cents, consumers showed a preference of four to one for the full-ripes over the green-ripes. The station showed that tree-ripened peaches could be brought out of the orchard, prepackaged in the packing shed, and delivered to the retail market in satisfactory condition for immediate use, at little loss. The loss for five different deliveries totaling 3,404 pounds was 18 pounds, which was an average loss of 0.5 of 1 percent.

That consumers prefer their peaches ripe was also the conclusion in a study made by the Utah and Colorado stations in cooperation with the Department on consumer preferences in peaches in city markets in the Middle West. In the past western peaches have been shipped hard and generally arrive on the market in a firm condition. The western study suggests that peaches would have better market acceptance if they were picked as firm or firm-ripe so that they would be riper when they reached the final market.

Consumer carton for peaches

In cooperation with a cooperative growers' association and several package manufacturers, the New Jersey station developed a consumer carton for peaches. The package was made of light cardboard and featured a transparent window. It was designed to hold twelve 2½-inch peaches like eggs in an egg carton. Twelve consumer cartons were packed in a ventilated master container for shipment. Small shipments were made to a number of chain stores, and observations were made on consumer acceptance. The consumer package served several purposes. It provided the fragile tree-ripened peaches with maximum protection and they arrived in the wholesale market and retail stores with little or no bruising.

The retail store managers and the produce managers were well pleased with the package, since sales of it could be made quickly without weighing. In addition, loss and waste from spoilage were reduced and the customers were able to buy fruit unhandled by other shoppers. Whether packaged in cups or in partitions, the peaches looked very attractive at the retail store and were well received by consumer buyers.

Washington Delicious apples marketed in Chicago

The Washington station, in cooperation with the Department, made a comprehensive analysis of the marketing processes involved in marketing Delicious apples grown in the apple districts of Yakima and Wenatchee-Okanagan during the 1947-48 season in the Chicago consuming area.

Out of each dollar spent for apples by the consumer nearly 24 cents went for washing, grading, packing, cold-storage, and other services at the packing plant; 14 cents for transportation from the packing plant to Chicago; and 36 cents for wholesaling and retailing after the apples reached Chicago. The 26 cents left to the Washington apple farmer as his part of the consumer's dollar was based on the average price received at the packing house door for Delicious apples shipped to Chicago. Out of his share, the farmer had to pay all his costs of production, harvesting, and hauling to the packing plant.

Services at the packing plant or shipping point cost an average of $1.21 per box, ranging from $1.04 to $1.42. Freight charges took 73 cents a box, auction charges 9 cents, and wholesalers and retailers got an average of $1.74 per box. The apples retailed in Chicago at an average price of $5.13 per box. This left the Washington apple grower $1.36 per box at its packing house door for Delicious apples sold in Chicago. The $1.21 per box marketing charge at the packing plant comprised: Packing, 46 cents; box and lid, 38 cents; warehousing and storage, 21 cents; handling and selling, 13 cents; and miscellaneous charges, 3 cents. Of this miscellaneous charge, 1.5 cents a box went to the Washington State Apple Advertising Commission for advertising and related expenses, 0.9 cent for Federal-State inspection, 0.1 cent for discounting drafts at the bank, and nearly 0.5 cent for other expenses.

Consumers like prepackaged asparagus

Asparagus prepackaged on the farm is holding up better in quality than asparagus bunched and delivered in bulk, according to preliminary results reported by the New Jersey station. Asparagus wrapped in 1½-pound transparent bags made of cellulose acetate kept in a fine

condition for as long as 72 hours under ordinary room temperature. It sold faster than bunched asparagus and at a premium more than sufficient to cover added cost. In a related study, asparagus cut in the morning with stalks trimmed to the desired length was washed and delivered to a packing plant and put into 1-pound cardboard trays which were covered with a cellulose-acetate overwrap by machine. Consumer reaction to packaged asparagus at the point of sale was studied in stores of the Philadelphia-Camden area and found to be favorable. Produce managers in the large stores liked the packaged asparagus because it was easy to handle and no weighing was necessary.

Prepackaged lettuce preferred

The Indiana station reported in 1949 results of a study of the prepackaging operations of a wholesale grocer. The station found that in 1946 and 1947 costs were in excess of benefits, and that certain technological improvements and consumer attitudes were needed to increase the dependability of marketing prepackaged lettuce in the future.

Costs of prepackaging were reduced from 3.74 cents per package to 2.17 cents by making the packaging room more efficient and packaging only head lettuce. A conveyor belt and garbage-disposal unit were the greatest labor savers in prepackaging lettuce.

Volume of lettuce handled by the prepackager increased considerably during the packaging period. However, the increase was not necessarily due to the prepackaging, since volume remained high when packaging dropped off during the spring months. Prepackaging did not eliminate retail store losses. Stores that handled prepackaged lettuce in refrigerated display cases had lower losses than stores that handled bulk lettuce in nonrefrigerated cases. Refrigeration was more important than either prepackaging or germicidal lamp treatment in preserving quality and freshness in lettuce. The saving in labor and from losses in the retail store was not enough to cover the extra cost of prepackaging lettuce. Prepackaged head lettuce received better consumer acceptance than the other prepackaged products. About three-fourths of the people who had used prepackaged lettuce preferred it over bulk lettuce.

There are many unsolved problems in prepackaging, such as quality control, disposition of off-quality products, location of packaging, proper wrappers and containers, size of unit, storage, and transportation.

Marketing prepackaged sweet corn at low temperatures

Adequate refrigeration all along the line is necessary in the marketing of prepackaged sweet corn husked and packaged where it is grown. This recommendation grew out of an experiment carried on by the Department and the Florida station in 1949. Prepackaging sweet corn in the production area was found to have these advantages. It offered: (1) An opportunity for quick and efficient cooling which is of major importance, since the high sugar content of freshly harvested corn turns to starch unless the corn is quickly cooled—ideally just above freezing—and held at low temperatures; (2) it permits waste husks and cobs to be used as stock feed and fertilizer on the farm; and (3) it results in big savings in transportation costs, one truck of

prepackaged corn equalling about three truckloads of crated bulk corn.

Precooling the corn to the desired low temperature required a minimum of 20 minutes in the hydrocooler when the water temperature was from 36° to 38° F. Even though the packaging operations were carried on with speed—the corn went from field to cold storage in 45 minutes—the precooled corn warmed up several degrees during packaging. On the basis of this finding, further cooling in storage after hydrocooling was found necessary before the corn was packaged. The experiment points to the need for refrigeration improvements in trucks, particularly in air circulation in the trucks where prepackaged corn is to be hauled long distances in them.

Packing and shipping green-wrapped tomatoes

In a tomato-shipping experiment, the Kentucky station found that out of seven types of containers the bent-bottom, three-hoop, tub-type bushel baskets with Georgia-type crown covers and cardboard liner were the most satisfactory for shipping wrapped tomatoes from Murray, Ky., to Chicago, Ill., by truck. The greatest damage occurred in the lug when one to four tomatoes on the end row were crushed. Other losses incurred in transit resulted from packaging tomatoes so carelessly that they shriveled and failed to color, careless and rough handling by producers in packing and transporting tomatoes to the packing shed, and packing immature tomatoes. The type of packing, whether hand-packing or jumble-packing, made practically no difference in the condition of the tomatoes transported to Chicago by truck. As a result of this study the growers adopted a production plan to control disease and to improve handling and shipping practices.

Marketing packaged Florida tomatoes in northern cities

Twenty experimental shipments were made by the Florida station to northern cities by trucks or rail during the spring of 1948 and the winter of 1948-49 to compare the relative feasibility and economy of marketing tomatoes in open-field boxes, wire-bound boxes, pony crates, lugs, and prepackaged cartons. A history of the tomatoes in the shipments included notes on growing, condition of the plants in the field, method of harvesting, handling in the packing house, and on quality, size, and grade. The Department studied the condition of the tomatoes at the terminal markets. Changes in quality due to the container, temperature, or other factors were determined.

The unwrapped and jumble-packed mature-green tomatoes shipped in open-field boxes and wire-bound boxes arrived at the markets with little difference in mechanical injury or decay compared with those paper-wrapped and place-packed in lugs. Pink and ripe tomatoes received considerable mechanical injury in pony crates, and those in prepackaged cartons showed considerable decay.

The cost of prepackaging tomatoes was about 75 percent higher than packaging the same quantity in lugs. The net return to the grower was higher for prepackaged tomatoes and the quality was initially better than the average of those marketed in lug containers. The retail selling price of prepackaged and bulk tomatoes was about the same in two retail stores studied in Tampa in the spring of 1948. The volume of sales, however, was greater for bulk tomatoes. Tomatoes shipped in

bushel field boxes returned the grower slightly more than those shipped in lugs, due to the lower packing costs.

Marketing fresh South Carolina tomatoes in New York

Specialists of the South Carolina station, from a study of tomato marketings, reported that the market for South Carolina fresh tomatoes is limited largely to the New England and Middle Atlantic States. The average retail price of South Carolina tomatoes in New York City during June 1948 was $5.39 per 30-pound lug. Of this, $1.69 went to the producer and $3.70 to the middlemen. Waste and spoilage caused by decay, crack, insect damage, and bruises were costly items in the ripening and repacking of mature-green South Carolina tomatoes. An average loss of 27 percent was observed. Minor defects at the farm became major defects somewhere along the route to market. Defective tomatoes are thrown away after the marketing charges have been incurred. Since tomatoes placed in retail markets must be of high quality in order to make a profit, this research shows, growers in South Carolina should give special attention to the quality of the product leaving the farm.

Costs of growing tomatoes in New Jersey doubled

New Jersey grows more tomatoes for factory canning than any other vegetable. In a study aimed at helping New Jersey farmers to reduce marketing costs where possible, the New Jersey station found that the price New Jersey farmers received for tomatoes in 1948 was as much higher than prewar (1935-39) as was the average of all farm products in the State. Consumers' prices for tomato products rose less than most other food items during the period of inflation (1939-48). The cost of growing tomatoes more than doubled from 1940 to 1948. Labor costs increased more and fertilizer less than the average of all costs. New Jersey growers have increased yields and quality as a result of research on better varieties and methods of production.

Prepackaged Oregon late-crop potatoes

Merchandising practices in selling potatoes have improved greatly since 1940. Prepackaging is gaining in importance and there are few instances in which potatoes are displayed on sidewalks or front windows of retail stores. Furthermore, there is a better control of inventories. This is in part the result of better buying practices and to a better regulation of the movement of supplies from the shipping points to the terminal and retail markets. Improvements are still possible if added attention is given to limiting the size of the potato display to the amount that can be moved within a day or two.

In a survey made with 13 cars of Oregon late-crop potatoes, the Oregon station found that consumers prefer prepackaged potatoes in the open-type container. They are reluctant to buy in the solid-type paper containers when they have an opportunity to buy potatoes otherwise.

The official inspection records constituted the basis for the facts presented in this study. It is evident that there is measurable difficulty in obtaining a uniform inspection in the shipping, terminal, and retail markets. Frequent trips to terminal and retail markets by shipping-point inspectors would afford an excellent opportunity for these officials

to re-examine their work and learn more about the markets for which they are grading.

Consumers' acceptance of sized potatoes

The Maine station studied consumer acceptance of carefully sized potatoes in one market. Consumers not only accepted but the majority preferred potatoes that were carefully sized. While the comments and reactions of consumers were expressed in many ways, nearly five out of every six interviewed indicated that they preferred to buy potatoes carefully sized rather than potatoes of mixed sizes. There were many reasons given for the purchase of sized potatoes. Those frequently mentioned were: "You can buy any size you want," "there is a range in price," and "they cook uniformly." Those who preferred potatoes in mixed sizes indicated that this assured some potatoes for boiling and some for baking. This seemed to be the most common reason given for preference for potatoes of mixed sizes. There was some indication that if the sizing of potatoes increased the price, some consumers would be willing to accept the mixed size rather than to pay the higher price. At the same price they indicated a preference for sized potatoes.

Potato quality and price relationship

The Maine station reported a Northeast regional potato quality and price study made partly in cooperation with the Maine Division of Markets. Quality of potatoes in certain retail stores in Boston and in Maine markets was compared. Slightly over 73 percent of all lots of potatoes inspected in the Boston market were classified as fairly clean as compared with 88 percent in the Maine markets. The potatoes in consumer packages were slightly cleaner than those in bulk displays in all markets. In general appearance about 79 percent of the potatoes in the Boston market were considered "good" in appearance as compared with only 66 percent in the Maine markets.

The retail price of potatoes in the Boston market varied from 5.1 to 5.5 cents per pound, compared with 4.4 to 4.9 cents per pound in the Maine markets. A definite relationship might be expected between the price of potatoes and quality factors such as grade defects, size of tubers, and general appearance. However, because of wide variations in the quality of potatoes within the same lot, such quality factors cannot be closely associated with retail prices when potatoes in a lot are uniformly priced.

Requirements of a good produce market

The Michigan station last year completed analysis of an exhaustive study of Michigan's public produce markets made in 1945 and 1946. On 5 of the 34 markets, trading was exclusively or chiefly wholesale. The 1945 sales value of produce marketed totaled 16.8 million dollars. This amounted to 23 percent of the total value of the 6 leading fruit crops, the potato crop, and the 11 truck crops grown in Michigan for the fresh produce market. This research indicates that the successful produce markets are those that are under sound management, are efficiently operated, have adequate supplies, are properly located, have a suitable layout and facilities, are operated at reasonable cost, and where an effective system of price making is carried out. Such a price program is possible only when the forces of supply and demand can be

focused in a single market district in which sellers and buyers can operate freely and efficiently.

Work simplification at marketing centers

Often practices in handling farm commodities at terminal markets can be improved. This means not only a saving of money for the market management, but also for the producer by whom the commodity is delivered.

Labor efficiency raised in warehousing burley tobacco

A work-simplification study of the warehousing of burley tobacco in Kentucky, made by the Kentucky station shows that warehousing this crop, which is largely a hand job, requires a crew of more than 400 men working 40 hours per week for a year. In other words, more than a million man-hours of labor are required annually to handle the burley tobacco crop on the warehouse floors in Kentucky and adjacent States. In addition to this handling, numerous other workers are needed to deliver the tobacco to the warehouse, to haul the tobacco to the buyers, and to keep the records of delivery and sales at the warehouse. The high proportion of manual labor involved in handling the burley tobacco on the warehouse floor afforded an excellent opportunity for a work-simplification study.

Warehouse operations involve four cycles: Receiving and packaging, weighing and placing in lines for selling, breaking the rows and bunching the buyer's tobacco, and loading the buyer's truck. Custom, market regulations, and the nature of the product all affect these operations. The tobacco is sold rapidly in lots or baskets that average about 350 pounds. Each lot of tobacco consists of one grade. Since the tobacco is sold by inspection, each grade is placed in the pile on the basket so that each hand or bundle of leaves is accessible to the buyer. Each basket of tobacco, therefore, is round in shape with the head of each hand or bundle of the leaves outward. These baskets of tobacco are then placed in parallel rows in the warehouse for selling.

The Kentucky station reported results of an operational analysis of workers made during the 1947-48 marketing year. The workers were selected at random in order to establish norms and to study the methods used. Warehouse operations in handling the average 350-pound basket required about 45 man-minutes. Between 80 to 90 percent of this time was used in receiving and packing the tobacco, about 5 percent in loading the buyer's truck, and the rest in moving the tobacco on the warehouse floor. During the 1948-49 marketing year stop-watch records on selected crews of different workers showed that they packed from 2 to 2.5 times as much tobacco per minute as had been established as the norm for the first season. Motion pictures were taken of these efficient crews and micromotion analyses are being run to determine the efficient work procedures.

RURAL ECONOMY

Some economic studies having general application to the business of dairy farming have been reported in the section on dairy farming research. In other dairy economic research and in the branches of the rural economy other than dairying, the State experiment stations have

contributed much to better farm operations and the improvement of the level of rural living.

Research on costs of operation

Knowledge on what it takes to run a farm and to engage in specialized farm production is a necessary prerequisite to successful farm management. Such information is also important for county agents and extension specialists called upon to help farmers develop complete farm plans that include everything from soil management to production, marketing, and farm living. Capital investment, labor costs, natural advantages, and market practices and facilities are only a few of the factors that must be considered.

These factors vary by States and within States, and their analyses when published represent a major service that experiment stations are giving to farm operators in the respective States. Brief summaries follow of some of the research carried on along these lines and reported during the past year.

Principles of farm development

To provide information to farmers contemplating changes of importance in their farming, the Kentucky station, after careful analysis, suggested improved systems and farm practices for eight typical farms in the Pennyroyal Plains of Kentucky. For each of the eight farms studied, the actual layout, actual crop and livestock system, and the normal income returns, using average prices for 1936 through 1939, were compared with a suggested farm layout and a suggested crop and livestock system using improved practices to show the effect on returns. As a result of this farm-management research, the station has listed some general principles that can be followed by farmers and extension agents in planning a balanced and efficient program of soil improvement that will assure profitable production.

Mechanical cotton picker operation

The Mississippi station cooperating with the Department reports that the mechanical harvesting of cotton has progressed rapidly in the Yazoo-Mississippi Delta. During the 1948 harvest between 600 and 650 mechanical pickers were in operation in the area. This resulted in a marked reduction in man-labor employed in picking. Cost of operating picking machines per bale varied from $10.58 in 1945 and $19.78 in 1946 to $14.77 in 1947. Labor, repairs, and depreciation accounted for about 80 percent of picking costs. Picker efficiency averaged 92 percent in 1947, which meant a waste of 8 percent. Machine-picked cotton averaged one grade lower than hand-picked cotton in 1947.

Stock-share lease

The Kansas station studied the advantages and disadvantages of tenancy under the stock-share lease that is quite generally in effect in Kansas. The stock-share lease provides for joint ownership of livestock by the landlord and the tenant and for a joint division of the farm receipts and expenses. Almost invariably the stock-share lease returns higher net profits to both landlord and tenant than is obtained under other methods of leasing. The basic assumption of the stock-share lease is that the value of land and buildings furnished by the landlord is

equal to the value of labor, power, and machinery furnished by the tenant.

Not all the stock-share leases are on a 50–50 basis. Basically, landlord and tenant share in proportion to their respective contributions. Farm budgets and accounts enable one to determine what the shares of the landlord and the tenant really are. In practice it is simple to contract on a 50–50 basis. The stock-share lease is especially adapted to an arrangement whereby a father takes a son into the business with him. Thus the father becomes the landlord and the father and son together become the cotenants. Stock-share leases tend to correct the evils of tenancy, make the tenure of the tenant more secure, promote soil conservation, and help develop and maintain a more permanent agriculture and a more stable and wholesome community life.

Farm ownership in the North Central States

Experiment stations in the North Central region carried on research in land-tenure programs. Thirteen States cooperated, and the regional report was printed by the Iowa station. This report contains information on land valuation, land tenure, and the financial status of the people who in general make up the farming population of the States in the region.

According to this survey 87 percent of the owners had only one farm, whereas 10 percent owned two farms and 3 percent owned three or more farms. Of all the owners reporting in the survey, less than 8 percent were under 35 years of age, about 18 percent were in the 35- to 44-year-age group, 24 percent in each of the 45- to 54- and 55- to 64-age groups, 18 percent in the 65- to 74-age group, and 8 percent in the 75-and-over age group. The landlord groups were considerably older than the owner-operator groups. Almost one-half of the nonoperating landlords were 65 years of age and older. Of the women nonoperating landlords, 56 percent were 65 years of age and older.

In grouping landlords by residence, the survey showed three-fourths of all landlords residing within the same county in which at least some of their land was located.

How farm ownership is transferred from one generation to the next is exceedingly important. Only 3 percent of the owners reported completed transfers to the next generation, excepting sales to people outside the family. The proportions of owners who in the middle-age groups reported that they had made a will are as follows: From 25 to 34 years of age, 2 percent; 35 to 44 years, 9 percent; 45 to 54 years, 18 percent; and 55 to 64 years, 24 percent. As part of the process of transferring farms to the next generation, an appreciable proportion—20 percent—of the landlords reported that they rented farms to their sons and sons-in-law. The proportion of landlords renting land to close relatives varies from 24 percent of the landlords who do not operate land themselves to 14 percent of those still operating part of their land.

Farming in Montana's irrigation districts

The Montana station compiled information on farm-management practices in irrigation districts of that State. Extreme variations were found in the size and type of farms where sugar beets were not the leading crop, 65 percent of these being in dry cropland or rangeland. Farms that included dry land had a total valuation of land, buildings,

and equipment about 10 percent greater than those with irrigated land only. Ninety-five percent of the farms had tractors and 38 percent had two or more tractors. Farm-machinery investment varied from $270 per farm to $24,000. The sum of the values of the tractors, combines, and trucks was approximately one-half of the value of all machinery on the average farm. Gross income was about evenly divided between income from crops and from livestock, except on the largest farms.

Success in farming was related to size of farm operations. Farms in the middle-success group were characterized by a fairly large and intensively operated irrigated acreage plus a large amount of dry-land resources. Operators in the most successful group farmed a larger acreage of irrigated land less intensively and had about the same acreage of dry land. Efficiency of management in keeping farm expenses down was also a factor contributing to success. Efficient use of the scarce and high-priced factor of production was evident on the more successful farms.

Sweetpotato management in Louisiana

A management study of 89 sweetpotato farms made by the Louisiana station showed that they average 42.4 acres per farm. Tilled cropland averaged 30.2 acres, or 70 percent of the farm. Capital investment per farm averaged $7,444 with an average turnover of 2.6 years. Average crop-acres per man was 17.1 per farm. Farmers with large farms had larger earnings than those with small farms. Earnings increased with the increase in percentage of tilled land in cotton and sweetpotatoes.

Under conditions of short-labor supply the sweetpotato enterprise is at a disadvantage because of the high labor requirements. Sweetpotato planting extends over a considerable period and competes with cotton and corn operations. About 113 hours are required to produce an acre of sweetpotatoes, compared with cotton, 86 hours, and corn, 37.4. For all farms the yield of sweetpotatoes averaged 137 bushels and the gross value, 1946 prices, was $6,150. The total expense was $56.17 per acre, and the net returns were $93.98 per acre. Net returns to land, labor, and management were $127.91 per acre of sweetpotatoes.

To be successful in the areas studied farmers must obtain yields above average, have a farm of adequate size with a high percentage of the cropland in sweetpotatoes and cotton, and must obtain a more-than-average amount of work per man per year.

Berry- and fruit-growing costs in Oregon

From a series of cost studies, requested by fruit growers, covering the year 1947, the Oregon station reported the following results: The cost of producing strawberries on 1,170 acres yielding 3,529 pounds per acre averaged $531.59 per acre. Of this amount, the labor cost was $330. The other costs, including fertilizers, dusts, and sprays, general expenses, depreciation, and interest amounted to $201.59 per acre. Capital investment averaged $6,777 per planting or $574 per acre. The cost of producing red raspberries averaged $608.93 per acre. Of this, $460 was for labor. The capital investment averaged $6,395 per planting or $826 per acre. Cost of producing black raspberries averaged $374.12 per acre. Of this $246 was for labor. Capital investment was $2,609 per planting or $480 per acre.

The cost of producing loganberries averaged $440.97 per acre. Of this $310 was for labor. Capital investment was $3,339 per planting or $566 per acre. The cost of producing boysenberries averaged $470 per acre. Of this $330 was for labor. Capital investment averaged $3,841 per planting or $725 per acre. Cost of producing apples in 1948 averaged $507 per acre. Of this $284.31 was for labor. Capital investment averaged $19,975 per orchard or $1,230 per acre. Cost of producing winter pears averaged $436.89 in 1948. Of this $193.40 was for labor. Capital investment was $17,202 per orchard, or $1,457 per acre. Cost of producing Bartlett pears averaged $432.18 per acre. Of this $206.62 was for labor. Capital investment was $7,227 per orchard, or $1,381 per acre.

1948 sale prices of North Dakota land

The North Dakota station reports that the sale prices of farm land in the State continued upward through the second quarter of 1948 at about the same rate as during the preceding 7 years. During the third quarter, however, sale prices dropped in all counties except one. Volume of transfers was considerably below any comparable period since 1940. The proportion of cash sales remained about the same, but buyers' equity in credit transactions increased. Individuals supplied 55 percent of the credit and made nearly two-thirds of total sales. More than 80 percent of the buyers were farmers and about 87 percent of the farmer-buyers had previously been owner-operators. Within 24 months 14 percent of the tracts had been sold at least once.

Cooperative fire insurance companies

From a study of rural fire insurance risks the Kentucky station concluded that farmers' cooperative fire insurance companies play an important role in Kentucky's farm economy. The development of commercialized agriculture and progressively larger insurable values in farm improvements and property incident thereto, and the rise of modern insurance corporations competing for the farmers' business creates difficult problems in the organization and management of cooperative insurance companies.

An important problem of cooperative fire insurance companies is membership education. There is a danger that the membership may assume an exaggerated sense of security because of present successes and thus disenable themselves to meet emergencies which may lie ahead. Another problem is the classification of insurable risks. Such classification provides better distribution of costs and controls competition for the more desirable risks. Classification also rewards loss-resistant features through lower assessments and penalizes more hazardous risks with high charges for insurance. It also encourages the cooperatives to shift from post-loss to an advance-assessment plan.

One of the disadvantages of the cooperative fire insurance company is the absence of a reinsurance feature. Reinsurance warrants more thorough consideration than it has been given by most cooperative insurance companies. Still another problem is that of the revaluation of insurance in times of rapidly changing farm values. Timing these changes is vitally important. The simple methods of operation of the cooperative companies and the intimate relationships they maintain with farmer members have enlisted the support of these companies

by many thousands of farmers. This simplicity and intimacy, together with the low charges for insurance are the outstanding characteristics of farmers' assessment fire insurance companies in Kentucky.

Property taxation in Texas

Yearly reassessment of property in Texas increases the burden on tax assessors and prevents equitable distribution of taxation. Studies at the Texas station show that improvement in the tax system of the State would result in direct annual savings of between 2 and 3 million dollars to tax payers. Greater indirect benefits would result from better land-use practices, greater equality of the tax burden, and a sounder base of public revenues. The present involved system makes it difficult for the tax assessor to do a good job, especially in urban areas. Data from these studies are used by the Governor's Tax Commission.

AGRICULTURAL ENGINEERING

Since the days when Thomas Jefferson drew his specifications for a moldboard plow of least resistance, engineering research has been one of the greatest contributors to scientific agricultural progress. Although damage may have been done to our soils in the pioneer years of mechanical operation, the improved power machinery of today is rapidly making amends. Modern earth-moving operations and farm tillage are doing things that could not be done with horse, mule, and man labor. Beyond farm machinery, agricultural engineering research extends, of course, into many fields. It is basic in dealing with farm structures. It is basic in research dealing with irrigation. It is basic in finding short cuts to laboratory research. It has made some fundamental contributions both in electronics and in the field of physics referred to as ultrasonics.

Equipment studies and improvements

The improvement of ordinary farm equipment and gadgets grows to a considerable extent out of ideas farmers contribute as a result of practical use in the field. Ideas that come to the experiment stations along these lines are usually passed along to the equipment manufacturer, unless they represent original contributions that are patentable, in which case farmers are advised to obtain patents. However, in their search for answers to major farming problems station engineering research makes many practical contributions.

Mechanization justified by 35 acres or more

According to the North Carolina station farms with above 35 acres of arable land in that State justify mechanization from an economic standpoint. A tractor should be used 40 or more days per year to pay for itself. This goal may be reached by home work plus contract work. The station found indications, however, that a 100-bale cotton crop is needed to justify an $8,000 cotton picker. One of the greatest advantages of mechanization is that with it the farmer can complete the various operations at or near the most favorable time.

New self-feeding hay bin

A round, self-feeding, hay-curing bin which cut in half the labor incident to feeding 200 beef cattle was developed by the Tennessee station. The actual time saved amounted to 2½ hours per day for two men and a team of mules or horses. In addition to the considerable saving in chore time, the bin provided increased storage space and insured better quality hay. Use of the self-feeding bin on dairy farms will save 1½ hours required to feed a ton of hay.

New barn hay-curing equipment

The Massachusetts station reports progress in its effort to find a haying tool that is not as expensive as the mechanical drier and that will make it possible to dry hay in the barn. Barn drying is an important consideration in the State, where farmers must feed hay and where rain during haying weather often interferes with proper drying. The station found that large air volumes are desirable to get an increased drying rate. Under the climatic conditions prevailing at the station during the test periods a 2-blade, 54-inch-diameter fan run with a 5-horsepower motor provides evaporating capacity equal to that furnished by a 4-gallon-per-hour oil heater.

Improved tobacco-curing equipment

The North Carolina station, in cooperation with the Department, has carried on research on curing bright leaf tobacco. Fuel-burning equipment studied included facilities for using wood, oil, anthracite, and bituminous coal. The station has reported that, although tobacco growers were using an average of 22.3 gallons of oil per 100 sticks of tobacco cured, research at the Tobacco Branch Station at Oxford demonstrated that good cures could be obtained with half that amount of fuel. By installing ventilators, insulation equipment, fans in the flue system, and other devices recommended in the studies, the station estimated a potential saving of over 4½ million dollars in the State of North Carolina alone. Similar work has been carried on at the Georgia Coastal Plain station at Tifton.

Mechanized sugar beet production

The Colorado station is engaged in research to eliminate much of the hand labor now being used in sugar beet production. Good progress has been made in the development of planting and thinning machinery and harvesting equipment. Recently, it was found that one device which presses a furrow into the soil instead of throwing out soil to form a furrow, gave outstanding results in improving seedling emergence.

Storage tests using forced ventilation for temperature control show that 50 percent of the sugar now lost in storage can be saved. This would give a potential saving of $800,000 to the beet sugar industry if universally practiced.

Tree-planting machinery

The Indiana station designed the Purdue Tree Planter, intended especially for planting trees on small areas but also equally suitable for use on most large commercial orchard sites. This planter will fit into the equipment needs of the fruit farmer at a price that is within the

dollar range of the ordinary tractor plow. The planter has helped make possible the planting of trees at one-fourth the cost of hand-planting.

Electronic lemon sizer

An electronic sizer, having a capacity of 270 lemons a minute, has been developed by the California experiment station. The sizer operates on the principle of the electric eye. The "eye" registers the intensity of shadows cast by lemons of different sizes and shapes as they fall individually from a table through a narrow light opening. The amount of current flowing through the eye controls the opening and shutting of trap doors for six sizes of field-run fruit. A pilot model is already in use as a sampler for determining the producer's equity in shipments taken from both small and large lots. It promises to speed up materially the grading of lemons for size. The principle is now being applied experimentally to electronic color sorting.

Supplementary irrigation in Midwest

Basic research in soil moisture and soil porosity at numerous stations has led soil scientists and engineers in midwestern and eastern States, where soil moisture is replenished every winter, summer rainfall generous, and drought periods rare, to investigate the practicality of supplementary irrigation. Such research is directed at soils with low water-holding capacity, as the sandy soils of Indiana, New Jersey, and Michigan. Since air is as important to plant roots as water overwatering can readily occur in a region where a rainy period may follow an irrigation. Therefore, only highly porous soils should be irrigated. On such soils the Indiana station reports yield increases through irrigation on corn of 11 bushels and more per acre.

New valves for using anhydrous ammonia

During the past year the Louisiana station, in cooperation with the Department, designed and tested valves for releasing a uniform amount of anhydrous (water-free) ammonia per acre, regardless of tank pressure. This valve is now being manufactured and is available to farmers at a very reasonable price. Several other types of valves that had been offered farmers were tested and ruled out for practical farm use. The station also carried on research in cooperation with seven different engineering companies to develop equipment for storing and distributing anhydrous ammonia fertilizer.

The use of this new fertilizer is spreading rapidly in the South. About 1,000,000 acres of Mississippi cropland were fertilized with anhydrous ammonia during the 1948-49 fiscal year. The Mississippi station estimates that, since this new method of fertilization was first devised and applied in 1947, total farm income in the State has been increased about $75,000,000.

The possibilities of anhydrous ammonia as a fertilizer had long been recognized by soil chemists, but not until practical means of using it on land were developed by the Mississippi station could its real value be appreciated. The ammonia gas is readily soluble in water, provides a desirable alkaline reaction, and quickly releases its nitrogen and hydrogen to combine with other elements in forming compounds needed in organic synthesis. Anhydrous ammonia is twice again as light as air and must be applied with special equipment.

Radiant-energy traps studied for corn borer control

The Nation's bill for European corn borer damage to field corn amounted to $103,000,000 in 1948. The Indiana station, in cooperation with the Department, has carried on research aimed at a possible method of corn borer control through use of radiant energy and electric traps that kill the female moth before she deposits her average of 400 eggs. During the season of 1947 a field study was made using six narrow-band sources of energy to determine the wave length of energy most attractive to the insect. The ultraviolet region between 3,250 and 3,650 angstroms attracted the most corn borer moths. The finding was further verified in laboratory tests made in 1948.

In further intensity studies made in the field in 1948 it was found that higher intensity sources attracted more moths but not in proportion to the increase in intensity. Field tests were again made in 1949 on control, using the ultraviolet sources which radiate in the region most attractive to the moths, and also on intensity. Although the degree of control has not yet been exactly established, results show that there is a definite decrease in corn borer population within a 100-foot radius of each radiant energy trap.

POULTRY RESEARCH

The total estimated value of chickens on United States farms in 1948 was $667,597,000; of turkeys, $30,989,000. Agricultural research devoted to poultry is, therefore, of considerable economic importance to farmers. The modern poultry flock has come a long way from the old time scratch-as-scratch-can days in the barnyard. Hatchery incubation and chick distribution by hatcheries are now widely accepted by most farmers. The modern commercial poultry farm now often includes chick batteries, laying factories, and numerous other features that promote forced broiler and egg production. These offer money incentives to producers, but they also warrant extreme care if disease and its spread is to be avoided and if a business is to stay out of the red. Thoughtful poultry growers are relying more and more on the various researches in poultry science at their State experiment stations. Breeding, nutrition, and parasite control make up some of the important fields of research that are contributing greatly to progress in present-day poultry farming.

Breeding for resistance to disease

Considerable progress has been made in recent years in the field of breeding disease-resistant chickens. The Auburn strain of White Leghorns, developed by the Alabama station through selective breeding to decrease adult mortality, shows excellent possibilities. During the past year pullets of this strain that were hatched and raised in comparison with outstanding American strains from California, New York, Florida, and Minnesota, were far ahead in livability and second in rate of lay. The adult mortality of unculled females from 5,000 pedigreed chicks grown to maturity and trap-nested for 1 year was only 18 per cent, the lowest since the project started 14 years ago. The hens averaged 202 eggs each, next to the highest production ever attained at the Alabama station.

Fowl-typhoid-resistant Leghorns

Cross-breeding of strains of birds that were resistant to and susceptible to fowl typhoid showed that the factors for resistance that were segregated in the third generation displayed partial dominance. From these segregates resistant lines were formed that were closely similar to the susceptible birds in their other characteristics. The genetic resistance of White Leghorn lines developed at the Iowa station was shown to be transmissible to other commercial stocks. The commercial importance of fowl typhoid led hatcherymen to request the station to make its method of selecting strains available to them. They have sought the most resistant strains in their flocks and are now breeding from these families to establish better stock as source material for their hatcheries. Crosses with the station's resistant strains were utilized to introduce resistance into other strains.

Of especial value is the finding that genetic resistance to fowl typhoid is closely associated with a higher-than-average body temperature. Resistant strains consistently evidenced normal temperatures from 0.2° to 0.4° C. higher than susceptible strains. It was noted that resistance is lowered within both resistant and susceptible strains when body temperature is reduced by brooding at low environmental temperatures.

Resistance to coccidial infection

The Hawaii station is using genetic principles in an attempt to increase the resistance of chickens to coccidial infection. It has developed resistant and susceptible lines. The Hawaii station workers artificially inoculated 14-day-old chicks from matings within the two lines with approximately 125,000 sporulated oocysts. They recorded chick mortality due to infection from 4 to 10 days after the inoculation.

The chicks from the specially selected strain proved to be much more resistant to protozoan *Eimeria tenella* than did the chicks from the susceptible strain. Of the former, 80.7 percent survived. Of the latter, only 14.5 percent lived. The difference in resistance was 66.2 percent. In continuing this study the Hawaii workers are testing chicks from other nonprogeny-tested males and females from the two lines, as well as chicks from parents that are entirely unrelated to the stock developed in this project.

Breeding for broiler production

The poultry industry has paid particular attention in the past few years to research dealing with the development of more efficient broiler-type strains of chickens. National interest has been stimulated in this problem during the last 3 years by the "chicken of tomorrow" contests, sponsored by a national food distribution chain and carried on cooperatively by poultry producers, State extension services, State experiment stations, and the Department. Experiment stations have concentrated their efforts on developing specialized broiler-type strains of birds. In the selection of strains and in the crosses made, emphasis has been placed on growth rate, feed efficiency, feathering rate, amount of breast and thigh fleshing, and level of egg production in the parent stock.

Barred Rock broilers in Delaware

The Delaware station reports research with Barred Plymouth Rocks in which meat-type matings produced the most desirable and efficient meat-type chicks. Preferential matings of egg-type males and meat-type females within the breed gave more desirable offspring for meat purposes than did reciprocal matings. The studies showed that inherent differences in efficiency of feed utilization exist and that a high efficiency apparently is associated with rapid rate of growth. Numerous factors controlled rate of growth inheritance.

Poor feathering eliminated in Mississippi strain

The Mississippi station reports success in its efforts to eliminate poor feathering in its strain of New Hampshire broilers. Baby chicks and hatching eggs have been released in the State for use in comparative breeding.

Early-feathering broiler strains in Oklahoma

Early-feathering strains of broilers were not available in Oklahoma until a few years ago. This lack forced Oklahoma poultrymen to buy out-of-State chicks at an additional cost of approximately 6 cents per chick marketed as broiler. This additional expense over the past 7 years has been estimated around $206,960. The Oklahoma station has developed early-feathering strains of White Plymouth Rocks, Barred Plymouth Rocks, White Wyandottes, and New Hampshires. Eggs from these breeds have been distributed to the various hatcheries in the State so that any farmer can secure rapid-feathering stock.

Breeding of uniformly dressed carcasses

In 1948 broilers contributed over $18,000,000 in gross profits to the poultry industry in North Carolina. Poultrymen in the State appreciate the contributions of their station toward making such income possible. The North Carolina station has made special efforts to develop strains of New Hampshires and Barred Plymouth Rocks that would yield high-quality and uniformly dressed carcasses. Last year there was a difference of 0.7 pound in weight between the highest and lowest rating strains whose body weight was taken at 12 weeks of age. These strains had been taken from the same hatches, fed the same feed, and managed in the same manner. On the basis of 1,000 broilers, a farmer who selected the highest rating strain by weight for broiler production, would have 700 more pounds of meat to market at 12 weeks of age than if he had chosen the lowest rating strain.

Crossbred broilers

The Arkansas station found that a cross of White Wyandotte cocks and New Hampshire hens gave offspring that weighed an average of 3.46 pounds at 12 weeks, a heavier weight than that of any of the other birds studied, including popular strains of purebreds in the stock. Information resulting from this research has been responsible for the present wide use of the White Wyandotte (male) × New Hampshire crosses in the broiler industry. Last year gross sales in broilers and hatching eggs amounted to at least $3,000,000. The cross is increasing in every major broiler area in Arkansas and is primarily responsible for the encouragement of hatchery supply flocks in the State.

Improving autosexed breeds

For years many workers both in this country and abroad have endeavored to develop breeds of chickens whose sex can be told at hatching time. These efforts have produced the Legbar, Cambar, Ancobar, Oklabar, and others. Unfortunately, none of them so far have proved profitable as egg producers. An effort is now being made by the Oklahoma and New Jersey stations to improve the productiveness of autosexed breeds.

The Oklahoma station developed the Oklabar breed more than a decade ago. Sex separation was made possible by superimposing the inheritance for barred feathers on a chick down color similar to that of the Light Brown Leghorn variety. The Oklahoma workers have since attempted to improve body size and performance. Pedigree breeding studies have been conducted with the Gold Oklabar, Silver Oklabar, and Creole Leghorn (Legbar). Performance of the Silver Oklabars has been improved materially. Many hatcheries throughout Oklahoma are requesting stock. The Silver Oklabars that have been released for field trials have proved fairly successful. Further selection and breeding of Silver Oklabars is going on for uniformity of growth, egg production, and hatchability, and tests will be made on similar combinations of down color for sight sexing.

Legbar-Danish Brown Leghorn crosses

New Jersey's original cross to produce the Legbar was a Barred Plymouth Rock male mated with Brown Leghorn females. The original parents were very poor layers, so the resulting Legbar breed averaged only about 70 to 90 eggs per year. In an attempt to raise production the New Jersey workers imported some Danish Brown Leghorns that were fairly good layers and crossed their Legbar males with the Danish Brown Leghorn females. This cross increased egg production from about 90 eggs to over 150 eggs per bird. The females from this cross were automatically Legbars in color and breed true; but this was not so with the males. Therefore, the New Jersey station had to test the males to find true color breeders and mate them to the pure Legbar females. The Legbars now have the desired egg size and color, but their egg production is still below that of the White Leghorn. Their general body size is much more desirable, and the birds mature quickly and possess very desirable meat qualities. The New Jersey station continues to strive for higher egg production. It will attempt to produce hybrid vigor by crossing the Legbar male with the White Leghorn.

Vitamin B_{12} and other B-complex factors in poultry nutrition

Feeding chickens in order to get results in the form of eggs and meat requires adequate knowledge of the principles of nutrition. The agricultural experiment stations as well as the Department are annually contributing a sizable amount of new knowledge in this field.

Maryland poultry research helps isolate crystalline B_{12}

One of the most important announcements in the field of nutrition in 1948 concerned the isolation of B_{12}, the new vitamin that shows promise in combating pernicious anemia in man and in improving human nutrition, as well as improving the nutrition of livestock and

poultry.[6] The microbiological work that led to the preparation of this new vitamin in crystalline form was done by the poultry department of the Maryland station.

Relationship of vitamin B_{12} to animal protein factor

At most stations research on vitamin B_{12} during the year was carried on with B_{12} concentrates. The problem now is to obtain the pure crystalline form of this vitamin in sufficient quantity to carry on comparative research. The Wisconsin station found that pure vitamin B_{12} can apparently replace the animal protein factor activity of condensed fish solubles and injectable liver preparations. Vitamin B_{12} administered orally or parenterally completely counteracted a thyrotoxic condition in chicks produced by feeding a diet containing iodinated casein.

Results of experiments carried on by the Idaho station showed that the B_{12} concentrate used in the study was as capable of promoting chick growth and hatchability as several crude sources of the animal protein factor.

Possible relationship between B_{12}, choline, and betaine

The New York (Cornell) station has developed an improved method for the determination of vitamin B_{12} microbiologically and a successful procedure for making highly purified preparations of vitamin B_{12} free of other unidentified vitamins required by the chick. It has gathered evidence that an interrelationship exists between vitamin B_{12} and two other nutritive factors, choline and betaine. In the presence of vitamin B_{12} the amount of either of the latter factors required in the diet is greatly reduced. The amount of vitamin B_{12} required by the chicks fed the New York experimental diets appeared to be between 1 and 2 micrograms per 100 grams of feed. Since the chicks used in the studies were depleted of their vitamin B_{12} reserves, it is probable that the requirement of normal chicks is somewhat less than this.

Folic acid and unidentified factors

In a study by the Maryland station on the nutritive requirements of poultry, it was found that a level of folic acid of from 26 to 34 micrograms per 100 grams of diet is required for normal hatchability of eggs. The 26 micrograms are adequate for normal production and fertility. Although no apparent differences were observed in down color and weight at hatching time of progeny as a result of low folic acid content of the maternal diet, the rate of growth, the degree of abnormal feather pigmentation, and the incidence of faulty feet structure of such progeny were influenced greatly by a lack of this factor. From this study it appears quite possible that folic acid deficiencies may occur under certain practical conditions. In the work on the multiplicity of unidentified B-complex vitamins, at least one unidentified factor was strongly indicated. This unidentified vitamin is required for rapid chick growth and is present in liver and dried whey but is not identical with vitamin B_{12}.

The Indiana station has shown that condensed fish solubles contain an unidentified growth factor or factors which stimulates growth in chicks and rats and is distinct from all identified vitamins. In studies

[6] The significant research on vitamin B_{12} concentrates in dairy feeding is described in the article on page 9.

to isolate this factor it was found that the factor is soluble in water, in ethanol, and in mixtures of acetone, ethanol, and water; is insoluble in ether and chloroform; is not adsorbed by fuller's earth; is readily adsorbed by and eluted from Florisil; and is not precipitated by lead. A concentrate was prepared which was active at a level of two parts per million in the diet.

This factor is distinct from vitamin B_{13}, and there is some evidence that it is also distinct from vitamin B_{12} and other postulated growth factors. Work is now in progress to further characterize this factor, both chemically and biologically, and to determine its relationship to the so-called animal protein factors.

Factors in soil for growth and reproduction of chickens

Substantial growth response when top soil was added to a chick ration deficient in unidentified growth factor indicated that a factor necessary for chick growth was present in the soil. Studies at the Washington station in cooperation with the Western Regional Research Laboratory of the Department, demonstrated that many different bacteria, besides *Bacillus subtilis*, produce the chick-growth factor in highly significant quantities and that they might be used commercially in its production. Tests of commercial fermentation residues showed that a number, some of them byproducts of streptomycin production, are potent in the chick-growth factor and may promote growth as effectively as a practical chick diet or as a supplement of liver or fish meal. Other preparations had no value or even had a depressing effect when added to chick diets. Proper use of commercial fermentation concentrates now on the market may enable the replacement of expensive supplements as fish meal and liver meal in practical poultry rations, effecting savings of about $4 to $5 per ton on the basis of current costs.

The vitamin A needs of poultry

Vitamin A is absolutely essential in poultry feeds. The approximate 1.5 billion chicks hatched annually in the United States require over 150,000 billion units of vitamin A, or the quantity contained in 55 million gallons of cod-liver oil. Due to decreasing production of fish-liver oil, vitamin A from this source is becoming scarcer. Unfortunately both vitamin A and carotene are extremely liable to oxidation, especially during hot summer months. Consequently, large percentages of these nutrients are lost from their carriers or the feed mixtures before they are fed. Therefore, any information on the utilization of vitamin A precursors by poultry, and on the preservation of both vitamin A and carotene, is of great value to the poultry industry.

Vitamin A requirements vary

The Nebraska station compared the growth-promoting value of three alfalfa products for both chicks and poults. The station showed that, with present unit cost of vitamin A, dehydrated alfalfa meal was much superior to sun-cured meals. These experiments also brought out the interesting observation that White Rock chicks apparently needed a significantly higher amount of vitamin A activity than did New Hampshire chicks on the same diet.

Early use of mixed feeds in hot weather recommended

The Oklahoma station found that the use of antioxidants reduces the loss of vitamin A and carotene in mixed feeds during hot summer weather, but not enough to be of economic importance. Cold storage and sealed containers were effective in preventing vitamin losses in mixed feeds. Neither pelleting of feed nor coating it with cellulose acetate proved effective in preserving vitamin A. Young, succulent, green feed, either freshly cut or prepared as silage, proved to be an excellent source of vitamin A for poultry. The Oklahoma station recommends that poultry feeds be used within 2 weeks after mixing to reduce loss of vitamin A potency.

Temperature effects on dehydrated grasses and legumes

The Maine station placed dehydrated samples of grasses and legumes in tightly closed glass jars. These were kept in the dark for 1 year at respective temperatures of 75° to 85° F., and at 32°. Half of the samples had been blanched with live steam before drying. The samples held at 32° lost a small amount of carotene. Those held at room temperature lost most of the carotene. There was little difference in the average loss from blanched and unblanched samples.

Feeding vegetable proteins

For many years poultry nutritionists have been conducting research with concentrates processed from certain vegetable-oil plant seeds as sources of protein for poultry mashes. The successful use of such concentrates as the main or sole source of protein could lower the cost of poultry diets and provide a useful outlet for important byproducts of the vegetable-oil processing industry. Difficulties have, however, been encountered. Station workers have found that some plant protein meals apparently poison chickens. All of them seem to be deficient in certain essential nutrients.

Cottonseed oil meal made edible for chickens

The Alabama station used cottonseed oil meal as the principal source of protein supplement in experimental chick diets. Several commercial varieties of these meals were obtained from different manufacturers and were analyzed for gossypol, a substance toxic to chickens. The varieties having a low free-gossypol content produced good growth but not so good as from soybean-oil meal. The cottonseed-oil meal having the highest free-gossypol content killed all chicks at an early age. When this high-gossypol-content meal was treated with isopropyl alcohol for reduction of the gossypol content it gave fair chick growth and permitted all chicks to survive the 6-week feeding period. The free-gossypol content of the cottonseed-oil meals was also reduced by additional cooking but there were no significant differences in growth rates of the chicks fed. Different quantities of free gossypol were added to soybean meal diets until the gossypol content ranged from 0.01 percent to 0.07 percent. Chick livability and rates of growth increased as the gossypol content was reduced. The station is now seeking to determine whether the addition of certain growth factors will improve the feeding value of low-gossypol-content meals.

B_{12} as cottonseed meal supplement

The Texas station investigated the supplementing of cottonseed meal with amino acids and vitamin B_{12}. The results showed that commercial cottonseed meal low in gossypol is equal to soybean meal as a source of protein if it is supplemented with the amino acid lysine, or another protein concentrate high in lysine, and vitamin B_{12}.

Two methods for making linseed oil meal safe

Past experiments have shown linseed-oil meal to be a protein of very poor quality for poultry feeding. Poultry farmers who have used it have done so cautiously, having learned that feeding more than 2 or 3 percent of linseed-oil meal in the ration caused trouble for both chickens and turkeys.

The California (Berkeley) station, however, has found that either the addition of pyridoxine, or extraction by water, makes linseed-oil meal a satisfactory poultry feedstuff.

Process for making castor-bean oil nontoxic

The Nebraska station discovered that castor-bean oil meal repeatedly extracted with hot ethyl alcohol was nontoxic to chicks. Extension of castor-bean processing to produce a protein concentrate for poultry will make an additional 70,000 to 80,000 tons of protein concentrate available annually. The added value of castor-bean pomace as a feed rather than as a fertilizer may amount to over a million dollars annually.

Soybean-oil meal processing improved

The Michigan station found that improper heating of soybean-oil meal caused destruction of the amino acids, lysine and arginine, as a result of the reaction of these acids with the sucrose of the meal. Also lysine, aspartic acid, and glutamic acid were inactivated by reaction among themselves, and glutamic acid, cystine, and methionine were inactivated by reaction with sucrose. The California station, on the other hand, found that the nutritional value of the meal is usually high when at least 86 percent of its antitrypsin factor is destroyed by heat.

Preserving poultry meat

Carbon dioxide gives longer storage life

The Iowa station has been conducting studies on the preservation of cut-up eviscerated chickens at refrigeration temperatures above freezing. Bacterial counts on commercially processed cut-up birds are commonly very high, more than 100,000 bacteria per square centimeter of surface area not being unusual. The characteristic bacterial slime developing on dressed poultry consists largely of closely related species of *Pseudomonas*. These organisms are capable of comparatively rapid growth at refrigerator temperatures and show appreciable multiplication even at 0° C. It was found that storage in an atmosphere of carbon dioxide for a brief initial period would give pieces of chicken a longer over-all storage life than that of similar pieces stored only in air. With this treatment, growth of aerobic bacteria is checked. The maximum practicable CO_2 concentration that could be used in the storage of cut-up poultry was about 25 percent; higher concentrations caused rather rapid discoloration of muscle tissue. Short-time CO_2 storage might be

used to advantage in the shipment of meats and meat products from the plant to the retailer or distributor.

Wrapping poultry to prevent dehydration

Because frozen poultry suffers a loss through dehydration, commonly referred to as freezer-burn, methods of prevention of this loss and deterioration in quality are needed. The Minnesota and Indiana stations have been working on this problem. Minnesota has packaged dressed, eviscerated chickens in several types of commercial wrapping materials including locker paper, aluminum foil, laminated foil, cellophane sheets, pliofilm sheets and bags, Cry-O-Vac bags, Traver bags, and poultry boxes. Some carcasses were given a special ascorbic acid treatment to study its anti-oxidative effect; others were treated with ascorbic acid and a new anti-oxidative material, Krim-Ko-Gel. These birds were frozen soon after evisceration and stored under commercial frozen conditions for future physical, organoleptic, and chemical tests. According to results reported thus far the carcasses in the locker paper showed considerable freezer-burn; whereas those in pliofilm and aluminum foil were judged "very good."

The Indiana station has tried to preserve chickens in storage by applying a uniform film of polyvinyl alcohols (Elvanol) over the surface of the carcasses prior to storage. Although the film retarded freezer-burn to a slight degree, it was found not too satisfactory for retarding dehydration of poultry over long periods of time (periods over 60 days).

Turkey research

Turkey production is a farm enterprise that is particularly sensitive to technology. Important research is going on in such fields as breeding, feeding, and marketing of turkeys. Many turkey growers are cooperating with the Register of Merit and Register of Production phases of the National Turkey Improvement Plan sponsored by the Department of Agriculture. Modern slaughter, cooling, and dressing methods are making it possible for turkey growers to market their birds to advantage in and out of season.

Still-air incubators favored for turkey hatching

The New Jersey station last year carried on research to determine whether turkey eggs could be hatched successfully in forced-draft incubators. Station workers recorded observations on five hatches. On the twenty-fourth day they divided the fertile eggs from each hen so that half of them might be hatched in a forced-draft-type machine and the other half in a still-air hatcher. The still-air-type incubator showed considerable advantage over the forced-draft machine. There was, however, no difference in viability of poults hatched from either group. In this research solid-top pedigree baskets were also found much safer than pedigree baskets with wire-mesh tops.

Broodiness reduced in Bronze turkey hens

The North Carolina Station, through application of genetic principles in the breeding and selection of Bronze turkeys, has reduced the period of broodiness in turkey hens from 14.5 percent in 1942 to only 5.5 percent in 1948. The number of hens showing neither pauses over 5 days nor broodiness during the lowest year was 25.2 percent. In 1948 it

was 65.7 percent. Mortality for the first 6 months of the life of poults was reduced to 8.98 percent in 1948; of laying hens to 3.3 percent. The research also has resulted in improving materially the body types and laying performance of the strain. The percentage of young hens qualifying for the United States Register of Production was increased from 71.3 in 1943 to 79.3 in 1948. The project also revealed the statistical probability that only in 1 year out of 5 could North Carolina growers expect the maximum hatchability to fall before March 10 or after April 29. The most probable average date for maximum hatchability was April 4.

Corn and soybean-oil meal in turkey rations

In experiments at the Indiana station with turkeys raised in confinement, 25-percent-protein starting rations containing as much as 40 percent of yellow corn and 47.5 percent of soybean-oil meal, with no animal protein feeds but supplemented with minerals and vitamins, produced as satisfactory growth during the first 12 weeks as a ration containing meat-and-bone scraps and dried milk in addition to soybean-oil meal. From 12 to 28 weeks a 17-percent-protein all-mash growing ration containing 64 percent of yellow corn and 24 percent of soybean-oil meal with alfalfa meal, dried fermentation solubles, and minerals produced practically the same rate of gain as a ration with the same protein level containing both meat-and-bone scraps and soybean-oil meal.

These results show that yellow corn and soybean-oil meal, both of which are readily available in Indiana, can be used to make up almost 90 percent of the ration for turkeys raised in confinement. For turkeys on good pasture these two ingredients could comprise almost 95 percent of the growing ration since only minerals, in addition to the green feed, would be needed as supplement. The results of these trials also show that good turkeys can be produced without feeding oats, provided the corn is ground and fed in an all-mash ration in order to make the turkeys eat it during hot weather.

FARM ANIMAL RESEARCH

The State experiment stations are engaged in many phases of animal research that apply to more than one species of farm animals. In addition to the comprehensive summary of animal research that applies to dairy farming heretofore summarized, the following highlights on other station animal research represent important contributions during the past year.

Horses, cattle, swine, sheep

Practically every experiment station is engaged in research projects aimed at helping farmers engage successfully and efficiently in various fields of livestock farming. With improved pastures and winter grazing, for instance, there has been a tendency among eastern and southern farmers to engage more heavily in beef cattle operations, principally feeding.

Interest in the horse continues. The horse still has an economic purpose and value on many farms. Research on horses, therefore, is important at some experiment stations. Many of the Eastern States

furnish a natural habitat for sheep. Sheep raising on a small scale is of such a nature that it fits in well with many types of family farm operations. One of the principal hazards to sheep farming on eastern farms is that of destruction of sheep by dogs and wild animals, but this is a problem that can and may be overcome. Hogs represent one of the major investments by farmers. Currently there are a number of serious diseases baffling the swine industry. Constant research on these problems, carried on in the stations' and Department's research programs, will find the eventual answers.

Cause of some mare and foal losses

Foals, as well as human babies, can be saved from death resulting from conflicting blood factors. This was demonstrated by the Kentucky station during the past year. The causes of 40 percent of abortions in mares and of 20 percent of death losses in foals are still unknown. The station found that healthy foals being nursed by mares possessing the wrong blood factor would die. The station demonstrated that the fatal hemolytic jaundice resulting from a foal nursing its own mother with a different blood factor could be avoided. Station workers prevented losses of foals from 10 mares. The Kentucky discovery should help the horse-raising industry to avoid great losses. In connection with this project the Kentucky workers found that streptomycin could be used to reduce death losses from foals affected with the germ known as *Shigella equui.*

Crossbreeding beef cattle

The Ohio station reports that Angus-Hereford crossbred calves from Angus cows were heavier at birth than purebred calves. The reverse was true in calves from Hereford cows. The crossbred calves outgained purebred calves, with one exception, from birth to weaning. Calves from Hereford cows outgained calves from Angus cows from birth to weaning, but the reverse is true on pasture and dry lot. The crossbred calves showed greater feed efficiency and yielded a higher grade carcass and higher dressing percentage.

The Montana station, in cooperation with the Department, has conducted experiments to test the possibility of maintaining hybrid vigor through the use of sires from the beef breeds and of crossbred females. Purebred Herefords were compared with crossbred steers and heifers.

Shorthorn bulls × Hereford cows produced steers with significantly heavier weaning and final feed-lot weights, and gained more in the feed lot than did the purebred Herefords. However, slaughter steer and carcass grade differences were not significant.

When crossbred cows of the above breeding were bred to Angus bulls, the resulting three-cross steers were significantly heavier at weaning and final feed-lot weight than were the purebred Herefords. These differences were carried over to slaughter steers and carcass grades.

The three-cross cows bred back to Hereford sires produced steers that not only had significant differences at weaning and final feed-lot weights, but also gained more in the feed lot and were a higher grade as slaughter steers and as carcasses.

The study also revealed, that as a whole, the crossbreds produced a higher calf crop than did the purebreds.

However, it is pointed out that for range producers of feeder cattle, a disadvantage exists in that buyers tend to discriminate against cattle with mixed colors. However, this discrimination does not exist on the fat cattle market where the bases for purchase are on finish, quality, and yield.

Breeding range heifers as 1-year-olds

The Utah station reports that breeding range heifers as 1-year-olds does not seriously handicap their growth where feed is plentiful. In an experiment carried on over a period of 5 years, cows that had been bred as 1-year-old heifers had weaned 371 pounds more calf than cows which had not been bred until they were 2 years old. This amounted to $74.20 more return per cow figured at the rate of 20 cents a pound. Early breeding apparently did not stunt the animals. The average matures weight of the cows that raised their first calves at 2 years of age was only 8 pounds less than the average for the cows that first calved when 3 years of age.

Improved pastures for beef cattle

In Georgia station experiments on two improved pastures beef cows with calves averaged 540 pounds cattle gain per acre. Cows and calves on two unimproved pastures averaged only 183 pounds gain per acre. A calf crop of 92.5 percent was obtained on the fertilized pastures and of 71 percent on the unimproved pastures. The Georgia station claims that improved pastures can take their place as an added or substitute income enterprise on many cotton farms in Georgia.

Production of beef on pasture

The Indiana station has several pasture mixtures and permanent grass pastures under study. The production of these pastures is measured by the gains made by beef cattle grazed on the different pastures. On permanent grass pastures responses have been obtained from lime, phosphorus, potash, and nitrogen. The response to nitrogen is especially marked in the spring season when moisture conditions are favorable for the growth of bluegrass.

Among the new legumes for permanent pasture is birdsfoot trefoil, a drought-tolerant legume, deep rooted, a prolific seed producer, and one which associates well with bluegrass. The combination of birdsfoot trefoil and bluegrass produced 334 pounds of beef per acre in 1948. In 1946, a record year, this mixture yielded 482 pounds of beef per acre. As methods of establishment are improved, birdsfoot trefoil promises to be an important legume for permanent pastures in Indiana.

In addition to the permanent pastures several legume-grass mixtures have been studied. Alfalfa-timothy mixtures and Ladino clover-bromegrass have been very productive in the grazing trails. Work is continuing to determine the best combination of legumes and grasses to use for beef cattle.

Rotation pastures for fattening cattle

Agronomists at the Iowa station have shown that savings in corn, hay, and protein by using alfalfa-bromegrass pasture varies with management of the pasture. One acre of this pasture saved $54.46 where the steers were pastured for 54 days, and then fed on grass for 84 days

and dry lot for 184 days. About one-half of the corn required in dry-lot feeding was saved by pasturing for 138 days before feeding was started. From 19 to 20 bushels of corn were saved by 1 acre of the pasture. Clipping studies revealed that first-year pastures gave 3 tons of forage per acre and second-year 4.2 tons. Second-year pasture is ready for grazing about 10 days earlier in the spring than the first-year stand. The percentage of bromegrass was always slightly greater the second year.

Further pasture research by the Iowa station showed that 0.56 to 11.86 bushels less corn per steer were required to reach the same degree of finish on pasture than in dry lot. A longer feeding time was required on pasture and daily gains were less. One acre of pasture had a feed replacement value of $19.52 when cattle were fed on full pasture, $22.16 when half fed on pasture, and $40.63 when grazed 126 days before corn feeding was started. The alfalfa-bromegrass pastures in this study are in a 4-year crop rotation where sod is left 2 years. All pastures were second-year stands.

Better forage yield through range reseeding

A comparison of methods of reseeding ranges made by the Utah station showed that forage yield could be increased by reseeding from 5 to 15 times over that obtained where land was allowed to reseed naturally. Early spring seeding was more successful than fall seeding. Wheat grasses seeded in the spring showed up best. On irrigated pasture orchard grass, smooth bromegrass, tall oatgrass, alfalfa, Ladino clover, and red clover, used in various mixtures, outyielded from 32 to 112 percent the old pasture varieties commonly used. The new mixture gave over 5,000 pounds of digestible nutrients per acre, equivalent to high-yielding alfalfa grown on the same land. The Utah station estimates that seeding varieties found to be best adapted from these trials will enable Utah farmers and ranchers to put 5 million acres of land under these far more productive grasses.

Greater feed value from poor-quality roughage

In digestion experiments carried on with poor-quality roughage, the Ohio station found that the nutritive value could be increased as much as 25 percent by a supplement of ash from both alfalfa leaf meal and soybean-oil meal. These meals are rich in mineral elements that improve the nutritive properties of low-quality roughages, which constitute a major tonnage of feed on farms and include such material as corncobs and timothy hay.

Corncobs for growing steers

Recently an experiment at the Indiana station, adding to earlier work done at Ohio, has shown that cattle can be wintered successfully with corncobs as the only source of roughage. The cobs were supplemented with soybean-oil meal, molasses, minerals, and cod-liver oil, and in two groups 5 and 10 percent of alfalfa was added. The cobs were ground through a hammer mill with a ½- or ⅝-inch screen.

The steers grown on corncobs gained on an average from 1 to 1⅓ pounds per day, whereas the steers fed clover-timothy hay gained only ¾ pound per day. It cost $12.54 less to produce 100 pounds of beef

using cobs as compared to hay. The cob-fed steers remained healthy, had glossy hair coats, and showed no sign of malnutrition.

Trace elements and animal nutrition

The presence or lack of trace elements in soil and their influence on plant and animal nutrition, continues, to a considerable extent, to present many important unsolved agricultural problems. In a study of mineral requirements of cattle on soils in the Everglades area of Florida, biochemists found that copper requirements for cattle can be determined only in relationship to the molybdenum intake of the animals; also that, beyond a basic level, a small increase in copper intake will counteract a relatively large intake of molybdenum.

It is shown that molybdenum follows the metabolic course of phosphorus and that the protective mechanism of copper functions more within the animal body than within the gastrointestinal tract. These metabolic studies are being continued with radioactive copper and phosphorus and have been broadened to include radioactive calcium.

The South Dakota station is engaged in an interesting experiment dealing with selenium poisoning. The station has kept two lots of 4-year-old cows on a large ranch continuously since they were born. One lot has had arsenic in the salt at a level of 37.5 parts per million, whereas the other lot has had plain salt. This experiment accords with similar experiments conducted with small laboratory animals, in which it was found that the use of salts containing very small amounts of arsenic has prevented selenium poisoning.

Effects of thiouracil and other hormones on metabolism

Considerable research is being devoted by experiment stations to the effects of using thiouracil and similar drugs to stimulate body growth of animals. The place and possible use of such compounds in the economy of livestock production for meat has not yet been established. A concerted attack must be made to establish a scientific basis for determining to what extent such materials can be used without danger of being incorporated in animal tissue, as the inclusion of any such drug or hormone might constitute a human health hazard.

The Pennsylvania station has carried on experiments in which thiouracil was fed to rats. Its effect was to increase economy of body gains. Neither digestion nor metabolism appeared affected in thiouracil-fed rats. They did, however, gain in fat and manifested a corresponding decrease in heat production. There is little doubt that thiouracil fed to ruminants would react similarly. If differences in gains corresponding to those in rats could be obtained in beef cattle, use of the drug would obviously have a practical farm application. Before its use can be recommended it must be determined by research whether thiouracil is dangerous to human health.

Studies were conducted at the Indiana station to determine the influence of stilbestrol and testosterone in the growth and fattening of lambs. Gains made by groups of lambs in which 12 and 24 milligrams of stilbestrol had been implanted were 0.49 pound and 0.50 pound per day, respectively, as compared to controls which gained only 0.35 pound per day. In two other groups in which 10 and 20 milligrams of testosterone were implanted (the larger amount in two separate implants of 10 milligrams with a 43-day interval) the lambs gained

0.43 and 0.41 pound per day, respectively. In all these tests the feed utilization per pound of gain was significantly less than the controls.

Further studies at the Indiana station tested the effect of thyroprotein on the growth and carcass composition of swine. The drug was fed in the feed at levels of 0.0088, 0.0132, and 0.0176 percent to three groups of pigs. Increased gains through 119 days after weaning were 30, 40, and 32 pounds, respectively, above the control lot, and the three experimental groups required less feed per pound of gain than the controls.

Improved swine through breeding

United States farmers are interested greatly in research dealing with swine improvement through breeding. This is readily understood in view of the fact that the total value of hogs on the Nation's farms in 1948 was an estimated $2,355,609,000.

The hereditary characteristics of swine depend entirely upon the breeding system used in their production. Until recent years the production of breeding stock depended entirely upon empirical methods developed by purebred breeders. Under the leadership of Department and State experiment station research, cross-breeding and line breeding of hogs has now reached a stage where practically any desired type of hog can be developed through application of genetic principles. Since 1940 when its line-crossing work started, the Indiana station has produced pigs which over a 3-year period exceeded conventionally bred purebreds and crossbreds by 14 percent in average weight per pig at 5 months of age. These same pigs showed a 5-percent advantage in efficiency of feed utilization from weaning to market weight.

New Hamprace hog

The Montana station, in cooperation with the Department, has developed the new Hamprace hog from matings of purebred unbelted Hampshires to Landrace in 1936 and subsequent selection and back crossing. In 1948 the blood percentages approximated 55 percent Landrace and 45 percent Hampshire, with a coefficient of inbreeding of the strain of about 32 percent. Production records for the period 1939-47 show that an average of 10.6 pigs was farrowed and 8.1 pigs were weaned per litter with an average weight of litter at 56 days of 248.4 pounds. The average daily gain in 1947 was 1.4 pounds and the average consumption of feed per 100 pounds of gain was 352 pounds. Slaughter tests have shown good quality of carcass. The Hamprace is a solid black hog. The back is slightly arched. The sides are smooth and uniformly deep. The hams are thick and carry well down to the hocks. The legs are medium in length. The head is small, rather narrow, and medium in length with a neat jowl. The ears are of fine texture, medium in size, and vary somewhat in carriage, ranging from slightly erect to slightly drooping. The disposition is very quiet and docile. The sows are quiet at farrowing time and suckle well. The breed is a good forager.

Amino acid needs of growing pigs

For the past 2 years the Indiana station has carried on feeding experiments to find out which of the approximately 19 amino acids found in animal and vegetable proteins are actually required by growing pigs.

To date these studies have demonstrated that the amino acids, tryptophan and lysine, are essential for the growth of weanling pigs. Corn, which is an important ingredient of swine feeds, is deficient in both of these important amino acids. The Indiana research has also determined the minimum level at which tryptophan is fed in the diet to obtain maximum growth. When this minimum level of tryptophan is fed, the growth rate of weanling pigs is equal to that obtained with similar pigs on the station's best dry-lot natural-grain ration. If the level of tryptophan in the diet is dropped below the minimum level by as little as 1 part of tryptophan per 1,000 parts of the diet, the growth rate of the pigs is reduced to one-half. Feeding experiments to determine the qualitative and quantitative requirements for the remaining amino acids are in progress.

Ladino clover pasture excellent for hogs

The Indiana station carried on hog-grazing trials in 1948. The results showed that pigs receiving a full feed of corn, protein supplement, and minerals on Ladino clover pasture gained faster and more economically than similar pigs on alfalfa pasture. Pigs without a protein supplement in the ration also made faster and more economical gains on Ladino than on alfalfa pasture. Furthermore, the gains of pigs on Ladino pasture without a protein supplement were almost equal to those of similar pigs receiving the supplement on alfalfa pasture, and at the same time were more economical.

The pigs on Ladino clover pasture consumed more pounds of dry matter than those on alfalfa pasture because of a greater consumption of the Ladino clover. The total digestible nutrient consumption, however, did not show any close correlation with the gain of the pigs. In all lots it was indicated that the quantity of protein consumed was more than adequate for the requirements of the pigs.

Trace minerals in ration increase hog gains

The Iowa experiment station conducted research on the importance of each of the trace elements, iron, copper, cobalt, manganese, potassium, zinc, and iodine. Fall-farrowed pigs were fed in concrete dry lots and were continued on the same level of trace minerals fed their dams during gestation and lactation. The results indicate that trace minerals may be more important for growing fattening pigs in dry lot than previously thought. Blood studies fail to reveal any significant differences in the hemoglobins of the pigs on the difference treatments.

Increasing B-vitamins in rations reduces baby pig loss

That death losses and failure to gain weight among young pigs suffering from nutritional enteritis can be checked by the use of higher levels of certain of the B-vitamins was established in experiments carried on at the Michigan station. Pigs suffering from this serious disorder responded with increasing growth to an injected solution of thiamine, riboflavin, niacin, pantothenic acid, and pyridoxine, followed by supplementing feed with these vitamins in quantities far above those available in ordinary swine rations. Autopsies of sample animals revealed that after the period of treatment the large intestine showed extensive repair, the characteristic surface discharge disappeared, and the digestive organs generally returned to normal. The Michigan sta-

tion has estimated that, when the information coming out of this research is put into general use, it will save Michigan farmers alone an estimated 5 million dollars a year in preventing pig losses and runty hogs.

Crossbreeding experiments with sheep

The Ohio station is conducting cross-breeding experiments to improve both wool and mutton production of sheep on Ohio farms. Crosses of F_1 Columbia sheep with Merino crossbred type ewes gave results superior to all other native types of sheep. They equaled those with Western ewes. They produced 2½ pounds of lamb for each pound raised under the previous Merino system. The crossbreeding has developed a type of sheep that produces 73 pounds of lamb per ewe at weaning time in flock breeding like that followed in Ohio. Thus the 3-breed crossing shows considerable advantage over the old system of grading up native stock.

The Utah station crossed range ewes of predominantly Rambouillet breeding with purebred Rambouillet, Columbia, and Targhee rams. The C_1 ewes (first-cross Columbia on range ewes) have consistently sheared more grease wool than R_1 ewes (first-cross Rambouillet on range ewes). C_1 ewes also had a longer staple and usually a lighter shrinking fleece. C_1 lambs were more than 5 pounds heavier than R_1 lambs. They graded a higher percentage of "grass fats" at weaning time. At prices prevailing last year, the gains made in wool and lamb production by the animals used in this experiment would increase wool returns from about 30 to 85 cents per head to about $1.15 more per head in lamb production when Columbia rams are used to grade up range ewes instead of Rambouillet rams. Targhee crosses were similar to Columbia.

Vitamin A needs of sheep on mountain range

Ewes kept on mountain ranges by the Washington station during the summer were found to store enough vitamin A to carry them through the winter months. Rams fed a ration low in vitamin A produced poor-quality semen and eventually had difficulty in standing and walking.

Stiff lamb disease cured by vitamin E

The New York (Cornell) station, after many years of research aimed at finding a cure for stiff lamb diseases, believes that it has found this cure in vitamin E supplements given in a certain way. The station had previously failed to find a cure through experiments with wheat-germ oil, a known vitamin-E carrier, because this product resulted in inhalation pneumonia in the animals. However, the station found that this disease was eliminated when the tocopherols (high molecular-weight alcohols) were mixed in the rations of pregnant ewes and newborn lambs. A similar lot of ewes did not receive the supplement. More than half the lambs from the latter group became stiff. It was found that these could be cured by subcutaneous injections of an aqueous solution of the disodium salt of *d,l*-alpha-tocopherol. Further work by the New York station has shown that the disease can be prevented or cured through treatment with vitamin E. Many other stations throughout the country have been engaged in research on this condition among lambs. All of them have made some contribution that led to the apparent final solution. Some of them will no doubt continue to study un-

solved questions relating to other so-called stiff lambs and the prevention of the malady.

PROGRESS IN VETERINARY RESEARCH

Experiment stations have closely synchronized all research in the veterinary field and research in the different animal and biological departments. Professional contact among technical research personnel is close and most cooperative. Related projects are closely integrated by heads of interested departments.

Examples of several outstanding veterinary research accomplishments during the 1948-49 project year have been cited in the sections on dairy farming and farm animal research. Reports on additional contributions along these lines follow.

Newcastle disease in poultry

Continued researches dealing with Newcastle disease of poultry conducted by State experiment stations are yielding results that should eventually mean control of this economically important disease. Because of its importance nationally, it is being studied by many stations on an inter- and intra-regional basis and in cooperation with the Department.

Simplifying Newcastle disease diagnosis

Several reports point to quicker and easier diagnostic tests for the Newcastle disease in poultry. The Wisconsin station reports development of a simplified test for Newcastle disease which at room temperature will give results in 20 to 30 minutes. The [Connecticut] Storrs and Minnesota stations have developed a rapid plate method, the results of which may be read in 5 minutes. The Virginia station is also experimenting with a similar test. In studies dealing with modes of spread, the Indiana station has found that bile is equally as suitable as blood serum for detecting Newcastle-infected birds.

The New Jersey station reports that treatment of respiratory exudates of Newcastle-infected birds with antibiotics freed the exudates of contamination and enabled isolation of Newcastle virus from eggs inoculated with such material. This method was determined by the station to be more satisfactory than attempting to filter out the contaminants and yielded a higher percentage of virus isolations. Isolation of the Newcastle virus in two men whose work was closely associated with Newcastle disease in poultry has been reported by Ohio workers. In each case there was a reddening and swelling of the eye and subsequent laboratory identification of the virus in the eye discharge of the patients.

Development of new vaccines

The Virginia station using a strain of virus of low virulence, demonstrated that birds of all ages that are susceptible to Newcastle disease can be successfully immunized by intranasal instillation of one to two drops of a 20-percent suspension of entire infected embryos in buffered saline. Vaccination with this virus by the "stick" method and by atomization gave unsatisfactory results. The hamster brain live-virus vaccine,

developed by the Maryland station has been widely acclaimed by Maryland poultrymen as a practical control measure for broiler plants and farm flocks. The vaccine doesn't make young chicks very sick, provides immunity lasting 3 to 4 months, and doesn't interfere seriously with the egg production of older birds. The Maryland workers studied the effect of this vaccine on monkeys. The results revealed that there may be a cross-immunizing effect with poliomyelitis. This might be an indication of a relationship between the Newcastle and polio viruses or it might be further confirmation of a phenomenon recently observed that certain viruses may interfere with the multiplication in a host of certain unrelated viruses.

Field trials of a commercially produced live virus vaccine in 12 flocks comprising approximately 30,000 vaccinated and 12,000 nonvaccinated control chicks have been completed by the California station. The results in the controls indicate that, when properly used, this vaccine is a safe and satisfactory product for immunizing young chickens. Although the present Newcastle disease vaccines have aided in the control of the disease, they have been found to have certain limitations that require further study. Frequent adverse reactions to Newcastle vaccination have been reported and instances of questionable immunity in some flocks have been observed.

It was originally assumed that chicks hatched from immune parent stock would carry over some protective immunity lasting the first 3 to 4 weeks of life. More recent observations have indicated that this passive protection is quite variable and cannot be depended upon for protecting chicks against the disease with any degree of certainty. Problems such as differential diagnosis between this and allied respiratory diseases, multiple immunization against Newcastle and other diseases at one time with a single injection, contamination of vaccines with other viruses, and involvement of human health, all need to be answered—which serves to keep the study alive and challenging.

Some kinds of mastitis cured by aureomycin ointment

The New Hampshire station experimented with use of the new antibiotic, aureomycin, in treating cows suffering from streptococcal or staphylococcal mastitis. Eighty-six quarters infected with mastitis streptococci were injected via the teat canal with 200 milligrams of aureomycin in an ointment base. When tested 14, 30, and in some cases, 60 days after treatment, 80 of the 86 quarters (93 percent) were eliminating no streptococci and were considered cured. Three quarters not cured by administering one injection of 200 milligrams of aureomycin were considered cured when re-treated with 400 milligrams of the material. A number of these quarters had failed to respond to previous administration of large doses of penicillin. Fifty-six quarters infected with mastitis staphylococci were treated with 200 milligrams of aueromycin and the infection was eliminated in about 75 percent of the quarters. The results obtained are the best so far reported for treatment of these two types of mastitis.

Diagnosing vibriosis through blood tests

The [Connecticut] Storrs station has been conducting studies of vibriosis in cattle caused by an organism known as *Vibrio foetus*. This is one of the important causes of early abortions or "breeding trouble"

in cattle, as evidenced by the isolation of the organism from fetuses aborted at 30 days. Evidence of vibriosis has been found in specimens from 11 States and Canada. This disease, when present, has been found to be a complicating factor in brucellosis control since farmers with herds negative to the blood test for brucellosis or with calves which have been vaccinated against this disease may mistakenly believe that subsequent abortions actually caused by *V. foetus* are caused by errors in reading blood tests or failure of the vaccine. The station considered its outstanding achievement in this project during the year to be discovery of an improved method of growing *V. foetus* on a solid-agar medium for antigen and vaccine production. This is expected to make possible the rapid expansion of use of the blood tests in diagnosis; also further research and control of vibriosis.

SUBSTANTIAL PROGRESS IN FIELD CROP RESEARCH

Research carried on by experiment station and Department plant breeders and geneticists has played an important role in the progress of American agriculture. Producers of practically every important farm crop have been able to improve yields through planting hybrids or improved varieties and strains. The most talked-about example and the biggest contributor from a dollars-and-cents standpoint is the corn hybrid. Rust-resistant wheats, helminthosporium-resistant oats, and improved and high-yielding varieties of grain sorghums are a few of many other outstanding examples.

Corn improvement continues

Corn breeding and new methods of corn tillage have come in for considerable study in areas where corn was not regarded as an important commercial crop in the past. In the South, for instance, corn experiments are showing much progress. Both the breeding of new adapted hybrids and the development of new tillage and fertilizer practices have raised considerably the amount of corn that may be grown on southern farms.

New corn hybrids for South

Tests conducted by the Florida station in northern Florida showed that the hybrid variety Dixie 18 produced about 40 percent more grain than the common varieties, and the Florida-1 20 percent.

The Louisiana station announced a new hybrid, Louisiana 521, developed in a cooperative project with the Department. On the basis of results obtained in this project, hybrid seed corn would bring an average increase in yield of 15 bushels per acre.

Corn hybrids for silage

Plant geneticists at State experiment stations can today produce corn hybrids that yield good grain under various soil and climatic conditions. What many people do not know, however, is that research is likewise putting emphasis on the development of hybrids suitable for silage and as grain and fodder producers. In addition to the outstanding research at the Illinois station, studies along these lines are also reported by the Connecticut State, Maine, New Hampshire, New Jersey, New York (Cornell), Oregon, and Wisconsin stations. The Wisconsin station

has developed an adapted hybrid for each corn-growing section of the State. These hybrids are widely used in other areas of the United States and Canada having similar growing conditions.

Cooperative corn trials conducted by the New York (Cornell) station in different parts of the State have given New York farmers good evaluations of many corn varieties now on the market and certain unreleased experimental hybrids. From these results the station compiled a corn hybrid maturity guide that farmers at different latitudes and at different elevations in the State can use to determine which corn hybrid will be likely to give them the best yield. The New Jersey station found in comparative hybrid variety tests that total green weight is not a very good indication of the total feeding units produced, a unit equaling 1 pound of dry-shelled corn or 4 pounds of dry stover. One hybrid having the greatest green weight ranked seventh in feeding units produced among eight entries in the test. The total feeding units followed the total weights of dry ears more closely than any other factor.

Ear weight and leaf nitrogen content related

The West Virginia station found a definite correlation between ear weight of corn and percentage of nitrogen in the leaf. The percentage of barren stalks was also related to the percentage leaf nitrogen content. Leaf analyses studies on 10 different hybrids indicated that maximum yield for all varieties occurred at the 3-percent leaf nitrogen content. Nitrogen side dressing is not recommended unless soil phosphate and potash supplies are known to be adequate. The information gained from these studies is having an important influence in improving corn fertilization practices in the State.

Cotton technology

Cotton growers are rapidly improving methods of cotton production. Not only is there a rapid trend toward mechanization, but growers are cooperating closely with their experiment stations in the improvement of varieties.

Hoeing labor reduced 61 percent

The Texas station compared mechanized cotton farming with production by mule and hand labor. The research showed that rotary hoes reduced hoeing labor by 61 percent, amounting to a saving of $6.50 per acre. Machine-picked cotton, compared with hand-picked cotton, brought 23 cents more per 100 pounds. The station tested two new power-operated stalk cutters. Both gave better results than the old roller type. Following the recommendations of the station, cotton farmers in Texas put into use about 1,000 sets of rotary hoe attachments in 1948.

Breeding cotton for Georgia conditions

The Georgia station, producer in cooperation with the Department of the foundation stock of Empire cotton, reports formation of a cooperative seed multiplication program to get adequate amounts of seed distributed among Georgia farmers. About 2,200 tons of registered seed grown in 1948 were distributed among growers. In the future the program will be entirely under the supervision of the Georgia Crop Improvement Association.

New cotton varieties

The New Mexico station announced a newly tested strain of the upland variety, Acala 1517. It yielded 37 percent more lint than the standard strain in 1948. It also had more uniform staple length and greater strength. Increased money value amounted to about $150 per acre.

The new Arkot 2–1 variety, released by the Arkansas station in 1948 after 10 years' research in cooperation with the Department, matures its bolls about 10 days ahead of other commercial varieties.

Wilt control by fumigation

The Mississippi station found a new approach to the control of fusarium wilt, one of the most insidious diseases of the cotton industry. Station workers treated wilt-infested plots with a fumigant, ethylene dibromide, at a rate of 20 gallons per acre. The treatment cost $40 per acre but this cost can be reduced to $15 per acre when fumigation is confined to the rows. In the Mississippi tests the fumigated plots yielded 2,000 pounds of seed cotton per acre, compared with an average of only 210 pounds on the untreated plots. This new method is said to destroy nematodes, microscopic roundworms which attack plant roots, and open tiny wounds through which the fusarium fungus enters the plant. Fumigation kills the nematodes and thus indirectly prevents much of the invasion by the wilt organism that might otherwise occur. The method also shows promise for control of tomato and watermelon wilt.

Handling damp cotton at the gins

The Louisiana station, cooperating with the Department, found ways in which cotton growers can reduce losses from damp cotton by greater care in handling and by taking it to gins equipped to handle such cotton. This was done by studying how wet weather and gin machinery are related to "rough" ginning. Louisiana growers, as a result of this study, were able to sell 47 percent of their 1948 cotton for what it was worth as compared with 12 percent the year before.

Improving tobacco quality

Popularity of American types of tobacco in many parts of the world is closely associated with improvement in quality resulting from the researches in planting and growing tobacco carried on by experiment stations in important tobacco-growing States. Reliable surveys made in the past year indicate likelihood of a continuing demand for American-grown tobacco blends. These continue as the favorite in cigarettes even in remote parts of the world.

New burley variety, Greeneville 21c

The Tennessee station has announced release of a new burley variety, Greeneville 21c, root-rot resistant and productive of a high percentage of cigarette smoking leaf, developed out of research carried on at the Tobacco Experiment Substation at Greeneville in cooperation with the Department. The research there involves breeding, culture, and chemical evaluation.

Costs of seedbed treatment cut practically in half

Kentucky tobacco growers require more than 40 million square yards of covered beds for growing the tobacco seedlings that are later set out in the field. Dealing with weeds in these seedbeds is a major problem. The Kentucky station, in connection with its project on chemical weed control in agronomic crops, found that use of methyl bromide in fumigating soil in tobacco seedbeds in the fall will prevent practically all weed germination the following spring. On the average, this method of treatment is estimated to cost only a little more than one-half as much as sterilizing the beds by steam or burning. The station also reports much better control of the weeds through fumigation.

Root rot problems nearing solution

A dual approach to the problem of brown root-rot and black root-rot damage in tobacco growing appears to lie in combination experiments on breeding resistant strains and on soil fumigation. Research in developing resistant strains has been carried on by some of the stations for over 15 years. The Massachusetts station began its breeding program in 1933. From 75 to 80 percent of the total acreage of Havana tobacco now grown in the Connecticut Valley is planted to black root-rot-resistant strains. Black root-rot-resistant varieties developed by the Kentucky station are estimated to have increased the value of Kentucky's burley crop by 30 to 40 million dollars a year. During the past year, the Kentucky station also reported progress in developing burley tobaccos resistant to fusarium wilt and mosaic, as well as burley and dark tobaccos resistant to wildfire.

The Tobacco Laboratory at Windsor of the Connecticut Agricultural Experiment Station is tentatively accounting for the peculiarities of the brown root-rot disease on the nematode hypothesis. Nematodes puncture the roots of tobacco plants, leaving tiny lesions that evidently furnish passageways for fungi or bacteria that complete the destruction of the roots. Plants so affected sometimes become stunted to such a degree that they're not worth harvesting. The Connecticut station has tried without success to bring such stunted plants back to normal growth through fertilization, cultivation, and irrigation. The Virginia station found that soil fumigation with DD mixture and Isobrome-D proved effective in reducing meadow nematodes in tobacco plant beds but not in eliminating these pests.

Small grain research

Research in the breeding of disease-resistant small grain and sorghum varieties has netted American farmers millions of dollars. The wheat farmer's nightmares used to alternate between threats of drought and fears of black stem rust. The former can be headed off by farmers, except under very severe conditions, by using soil and moisture-conserving practices. The latter can be minimized or entirely avoided by the constant vigils of plant breeders and pathologists.

The most severe outbreak of black stem rust occurred in 1935, with 23 percent of the wheat crop damaged. In 1937 there was a 9.3 percent loss; in 1944, 8 percent; and in 1946, 4 percent. The latter two outbreaks, although only fractions of that in 1935, are believed to have got their start because one of the rust-resistant varieties did not actually

turn out to be resistant to a new strain of black stem rust. It is because of this versatility of plant disease organisms, this tendency to develop new races to whose threat present resistant crop strains are not immune, that plant breeding investigations at the experiment stations are now generally accepted as a continuing service to farmers. Plant breeders must constantly be on the alert and ready to supply crop varietal strains that can ward off attack by new races of the disease organisms.

Wheat breeding

The Kansas station has developed hard red winter wheats that are resistant to leaf rust, stem rust, bunt, loose smut, Septoria leaf blotch, and hessian fly. Kansas selections include strains resistant to all races of bunt in the United States. The Indiana station in 1948 announced a number of extremely early leaf rust-resistant lines of soft winter wheat. These Indiana strains as a group yielded approximately 25 percent more wheat than the best standard strains in southwestern Indiana. The Washington station has released to farmers for general planting seed of its new soft white spring wheat Marfed. This variety, developed cooperatively by the Washington station and the Department, is particularly resistant to powdery mildew and to a considerable number of the common bunt races. It is more winter hardy than Federation, which it resembles in height and resistance to lodging. Flour milled from Marfed approaches that made from Federation in baking quality. The South Dakota station announced release of a new beardless spring wheat, Rushmore, developed through the regional wheat program in which the Department cooperates. Rushmore was developed from crosses of Rival and Thatcher. It combines all the good points of the latter, with especially good resistance to shattering.

Helminthosporium blight-resistant oats strains

The Arkansas station, in selections made from its crown-rust-resistant Arkansas Traveller variety of oats, reports promising new lines emerging. Some of these combine resistance to all common races of crown rust and helminthosporium blight as well.

Breeding adapted sorghum varieties

When the Texas station began its plant-breeding work with grain sorghums, one of its major aims was to establish varieties that could be adapted to mass production and economical harvesting through combining. Of the 18 varieties on the Texas State Certified list last year, 15 were developed at the Texas station. As a result, production of sorghum grain in Texas has increased to an estimated half billion dollars in the past 5 years.

New soybeans, field beans, and special crops

Monroe, a new pre-wheat soybean for northern Ohio, was developed by the Ohio station and the Department from a cross of Mukden and Mandarin made at Urbana, Ill. Compared to Earlyana, currently the earliest recommended variety in Ohio, Monroe is 4 to 5 days earlier, stands better, and is similar in height, yield, and oil and protein contents. It is 5 inches taller than Richland, ripens about 10 days earlier, and yields as well. Monroe does not have all of the qualities desirable

in an early variety, yet it surpasses existing varieties enough to warrant extensive use.

The Iowa station reports a new variety named Adams, developed in cooperation with the Department. Adams grew out of a cross of Illini and Dunfield. It is expected to share in the large acreage now planted to the Lincoln variety in central and southern Iowa. In station trials the Adams variety surpassed Lincoln in yield and in oil and protein contents.

Missouri's southeastern counties have long needed a soybean variety that can be successfully grown in rotation with cotton. Varieties previously grown in this section have been full-season varieties, well adapted to central Missouri but usually low in yield in the delta counties. After 7 years of breeding from a selected strain the Missouri station has developed the S-100 soybean, a medium-early, high-yielding, nonshattering, and nonlodging soybean with high quality seed. Development of this new variety makes it possible for farmers in southeastern Missouri to get the benefits of soybeans in rotation with cotton and still harvest a sizable crop of soybean seed.

A new productive field bean for Montana

The Montana station has released to farmers of that State a medium-early, high-yielding variety of field bean named Great Northern Montana–5. This new field bean is resistant to common bean mosaic and well-adapted to the bean-growing areas of Montana.

Improvement of legumes and grasses

The trend to a grassland agriculture in many parts of the Nation demands of experiment stations that they keep up with farmers' needs for seed of improved varieties of forage grasses and legumes. Many stations are engaged in developing superior types of such seeds.

New vetch variety, Doark

A new variety of vetch named Doark was released by the Arkansas station in 1948 which provides very good forage, combining this quality with prolific seed production and winter hardiness. Doark gave high yields in all sections of the State. It outyielded hairy vetch and also matured 2 weeks earlier.

Kenland red clover makes new yield records

Kenland red clover, recently released by the Kentucky station, is surpassing yields of other varieties heretofore classed as best. In 1948 from 15 to 25 percent more hay was harvested from 2-year-old stands. The outstanding merit of Kenland, however, is the long life of its stands. Three-year-old stands have produced twice as much as other adapted varieties.

Research in potatoes, sweetpotatoes, and sugar beets

The Maine station and the Department have worked together for years in research on potatoes. The procedures tested out in this research and resulting recommendations are of value to potato farmers all over the United States.

Preventing potato late blight rot

In 1949 results of joint experiments on potato late tuber blight conducted in the great Aroostook potato area were announced. No other potato disease can sweep in and cause so much damage in a short time. Late blight rot multiplies rapidly only when weather conditions are favorable but blight weather may come at any time during the season. If, as sometimes happens, blight kills the foliage before tubers have developed to marketable size, the crop may be a total failure. On the other hand, the tuber crop may be mature before the blight strikes down the vines. In such cases, although the yield may not be reduced, growers may lose up to 75 percent of the harvested crop through infection caused by blight spores accompanying potatoes into storage. Storage rot in many years represents the greatest loss.

According to the findings released in 1949, tubers can be harvested without sustaining much blight infection even in seasons when blight is prevalent near harvesttime. This can be done by delaying the harvest until well after frost has completely killed the tops or by killing the tops with a suitable chemical without waiting for frost. The tops can also be destroyed by a rotobeater.

The State-Federal potato improvement program has also produced potato varieties highly resistant to blight and possessing good market qualities. Some of the new varieties already available from the program, like Sebago, Kennebec, and Saranac, failed to develop tuber rot under conditions where Green Mountain and Katahdin developed a considerable percentage of rot. The Kennebec variety, released in 1948, is highly resistant to both foliage and tuber infection. It had no tuber decay in experiments in Maine where Katahdin and Green Mountain showed 50 percent or more infection.

Idaho potato disease identified as verticillium wilt

Growers in the well-known commercial potato-growing areas of Idaho had long known about "early dying" of potatoes. Some had mistakenly thought it to be a form of fusarium wilt. The true nature of the malady was misunderstood until the Idaho Experiment Station identified the causal organism as *Verticillium albo-atrum*. This identification will not only clear the way for possible development of resistant strains but will also enable intelligent working out of practices that may prevent much of the damage from this verticillium wilt. The Idaho station has already found that highly fertile soils resulting from rotations using alfalfa or clovers, heavy applications of barnyard manures, or commercial fertilizers, reduce yield losses. It is of interest and of great value for the potato grower to know that the verticillium wilt organism is present in the Idaho area, and also that the Idaho station has discovered that the organism has survived 7 years in soils cropped with barley and alfalfa that are not known to harbor the fungus.

New potato for western Nebraska

A new potato variety, Progress, was developed and introduced by Nebraska station as a desirable type of potato in western Nebraska. The Progress variety has shown considerable resistance to scab. The tubers rarely crack at harvesttime. The variety has a slightly long and somewhat flat red tuber, is mid-season to early with heavy set, shows considerable resistance to fusarium wilt, and is subject to growth

cracks but not to hollow heart or knobs. It is above medium in ascorbic acid content.

Preventing bacterial ring rot

The Iowa station carried on tests with potato planters which showed that a picker-type planter can become a disseminator of bacterial ring rot organisms. Under the conditions of the experiment, an assist-feed type planter did not spread the organism. Ring rot bacteria are highly infectious. No seed showing the slightest trace should be planted.

Early potato spoilage study

Three major causes of spoilage in early potatoes marketed from the Southeastern States are: (1) Use of varieties that bruise easily; (2) rough handling in harvesting and grading; and (3) holding the potatoes at high temperatures—above 70° F.—either during harvesting and grading or in shipment.

This information comes from a preliminary analysis of findings made during the past 2 years by research teams working at eight locations in the Southeast and at terminal markets in New York, Philadelphia, and Chicago.

The agricultural experiment stations of Virginia, North Carolina, South Carolina, Florida, and Alabama are conducting this regional potato-spoilage study, in cooperation with the Department, of growers and shippers in the region. Although the investigations are not near enough to completion for final evaluation and recommendations, they provide the following observations:

1. When grown under favorable conditions, the Sebago, a smooth, white potato, holds up unusually well in handling and shipping. The Bliss Triumph variety grown in much of the Southeast bruises easily.
2. On the average the greater the number of days between planting and harvesting the less are the potatoes subject to skinning. Killing of vines, practiced by many growers in the area, decreased the amount of skinning on potatoes of equal age.
3. High temperatures in the field account for heavy losses. Potatoes subjected to high rates of evaporation for 3 hours or longer developed scald (sunken discolored areas) even when the exposure occurred after they were crated or sacked in the field. Some scald developed after 1 hour's exposure.
4. Temperatures at the packing shed depend to some extent on how the potatoes are held. If placed in bins, racks, or boxes under cover at the shed, the potatoes cool off. Those held in field bags on trucks in line through the heat of the day warm up enough in the outside layers to cause high spoilage loss.
5. Most cuts and bruises during grading may be traced to long drops onto the sizing chains where these chains pass over the roller. This damage can be eliminated by proper padding.
6. Development of bacterial soft rot en route to market is closely related to the amount of cuts and bruises in samples collected before and after grading when temperatures en route are high. When the potatoes are effectively precooled, very little decay develops even though there are many cuts and bruises.
7. Potatoes of high quality from the Southeast will continue to draw premium prices in the city markets after the California crop comes

in. Sebago potatoes from South Carolina were of such good quality this past season that they drew good prices throughout the season. Although Southeastern growers have a common problem in spoilage, the causes vary widely with location.

New table-type sweetpotato

A table-type sweetpotato containing twice the amount of carotene of its predecessors has been developed by the Oklahoma station. It has a carotene content of about 60 milligrams per gram of dry matter and an ascorbic acid content of about 100 milligrams. The variety, named Oklahoma 24, is also tolerant to stem rot, a serious sweetpotato disease.

Organic mercurial for control of blackroot

A low-cost, practical method of combating blackroot, one of the most serious fungus diseases affecting sugar beet seedlings, that gives promise of stability in sugar beet production, was reported by the Colorado station. Control of blackroot by rotation is not practicable because the causal organisms can live in the soil many years. Because more than one kind or strain of fungus may cause the disease, development of resistant varieties is complicated. In preliminary trials with a number of commercial fungicides, the station found an organic mercurial which gave a 60-percent increase in healthy seedlings under the soil and climatic conditions prevailing in 1948 on certain Colorado sugar beet lands. A method was developed whereby this fungicide could be mixed with any amount of fertilizer at the rate of 1 pound per acre and at a cost of less than $1 per acre.

RESEARCH WITH FOREST AND SHADE TREES

Research with trees is a definite part of the experiment station program in many States. It may be closely integrated with departmental forest research, with the program of State forestry, or it may deal with practical farmer problems such as tree-cutting practices in the farm woodlot, harvesting and marketing practices for growers of Christmas trees, or with fundamental problems such as insect and disease control of trees.

Two-way control for Dutch elm disease in sight

The Connecticut Agricultural Experiment Station is carrying on two fields of research which point to eventual control of the dreaded Dutch elm disease. This important tree disease, which entered this country only a few years ago, already reaches from the Northeastern States as far as Virginia in the South, and Colorado in the West. If left unchecked, Dutch elm disease is destined to wipe out one of the most beautiful species of trees on the American landscape.

The insects responsible for spread of the disease are the elm bark beetles *Scolytus multistriatus* and *Hylurgopinus rufipes*. The immediate cause of the disease is a fungus, *Ceratostomella ulmi*, an internal parasite which grows in the xylem tissue, that portion of the tree whose primary function is to conduct water from the roots to the branches, twigs, and leaves. As the fungus grows and spreads internally lack of water causes the leaves, twigs, and ultimately the entire tree to brown and die. The

only time when this fungus parasite exists outside of the tree appears to be in the spring when the elm bark beetles feeding on elm twigs carry the disease from infested to healthy trees.

Experiments with chemotherapy

One approach to the control of the Dutch elm disease being made by the Connecticut station at New Haven is through chemotherapy. This is a relatively new field of plant research. The principle of chemotherapy applied to plants is similar to that employed for control of disease in human beings and animals. The theory is simple. It is to introduce into the host plant certain chemicals or antibodies that will halt the progress of the micro-organism causing the disease or counteract its ill effect. In the case of plants, however, efforts along these lines, carried on for decades have mostly ended in failure. The chemicals that were potent enough to prevent advance of parasitic fungi or chemicals usually injured the living tissue of the host plant beyond repair.

The Connecticut Agricultural Experiment Station has also experimented with many new synthetic chemicals injected into plants in greatly diluted form. Encouraged by results announced by the Rhode Island station in connection with another tree disease, the Connecticut station workers devoted intensive research over a 5-year period on the possibility of controlling Dutch elm disease by internal elm-tree medication. Injection of 8-quinolinol benzoate in measured dosages some 18 to 24 inches into the soil gave a measure of protection for periods lasting no longer than a year. The injections were made at various places in the doughnut-shaped area marking the tips of the root-system.

This method is being used on a limited scale in Connecticut parks, along streets, and in localities around centers of invasion of the disease. There is no assurance that present methods will ever provide 100-percent protection from the disease. This research, however, may eventually lead to a successful method of controlling a whole series of destructive plant diseases, commonly called wilts. These are caused by internal parasites that invade and clog the water-conducting channels of the plant. Among them are wilts of tomato, cotton, tobacco, melons, flax, and other important crops.

DDT checks elm bark beetles

The Connecticut Agricultural Experiment Station has also developed a companion method of fighting the spread of Dutch elm disease. DDT has been found to kill the elm bark beetles that spread the disease. About 200 large elms, apparently free of the disease, were used in the test. Half of these received spring applications of highly concentrated DDT solutions with a mist blower. The other trees on adjacent plots were left untreated. In the late summer only 4 in the DDT-treated plots were found to have Dutch elm disease, while 21 in the plots which received no treatment definitely had the disease and 6 more showed symptoms. The DDT treatment consisted of the application of either a 1-pound or ½-pound-per-gallon concentration in the spring before the first brood of bark beetles emerged.

An elm tree killed by Dutch elm disease deteriorates very rapidly and must be removed promptly to avoid the danger from falling limbs. It costs up to $150 or more to remove a large tree, including the stump and sidewalk repairs, in the Connecticut area, whereas the annual cost

of DDT treatment is only a fraction of this amount. A tree can be treated for many years for the price of its removal.

RESEARCH ON FRUIT TREES

Horticultural research is as old as the experiment stations themselves. In recent years, research has been responsible for many discoveries and innovations that have put fruit farming in the front ranks of the Nation's farm enterprises. From the large commercial orchardist to the individual farmer with a small family orchard growers have learned to place reliance on the technical leadership to be found at the State experiment stations.

Michigan increases cherry yield

The marked benefit derived from the experimental application of straw mulch or legume-hay mulch in cherry orchards by the Michigan station has led to a definite move among growers toward the use of sod mulch methods of management. On young trees the use of mulch was found to increase the yield of cherries up to 100 percent. In comparing sods composed of different grasses it was found that fescue sod was less beneficial than was Kentucky bluegrass.

Peach yields higher in Utah with light pruning

How severely should peach trees be pruned to give the best yield under Utah conditions? This question was answered in a test by the State experiment station of four methods of pruning. The methods tested varied from very light to very severe pruning, using the modified leader system. The lightly pruned trees yielded 141 bushels per acre. Only 49 bushels were picked from the heavily pruned trees. As the results of this experiment are accepted by the growers they are expected to increase State yields. Utah growers previously pruned peach trees severely.

Semidwarf apple trees give higher per acre yields

Spraying trees and picking fruit are two of the biggest cost items in operating commercial apple orchards. The Pennsylvania station has demonstrated that these costs may be lowered by planting semidwarf trees. In 1935 the station planted a block of 60 Rome Beauty apple trees grafted on Malling II rootstock. Because of their smaller size, these trees could be grown on a 20-by-20-foot area per tree. This spacing allowed for twice as many trees per acre as had been customarily planted in most commercial orchards. The trees came into bearing at 5 years of age. They yielded 637 bushels per acre in 1948 and over 550 bushels per acre in each of the two preceding years.

The Idajon, new dessert-variety apple

Idaho apple growers have long desired a dessert variety apple that would ripen for market ahead of Jonathans. In 1949 the Idaho station announced development of the Idajon apple, selected by the station from a cross between Jonathan and Wagener trees. The new variety is larger than either parent and has an attractive, nearly solid red color. It is ready to harvest about 10 days before Jonathan. Its flavor and other eating qualities are best shortly after picking. It is essentially an early fall variety intended for the early market.

Importance of prompt harvesting and cooling of apples

Apples, like potatoes and many other perishables, keep longer when their temperature is controlled at harvesting and immediately after. The Washington station showed what happens when there is too great a time lag between picking and placing apples under proper temperature control in the warehouse. Station workers marked 14,291 boxes of the red strain of Delicious apples in 16 private orchards in the Wenatchee area to show the date and hour of picking. Then they marked the time of arrival from the orchard at the warehouse. Only 29.3 percent of the boxes arrived at the central warehouse platform within the first 12 hours; 57.6 percent arrived during the first 24 hours; and 85.6 percent within the first 48 hours. The last of the marked boxes did not get to the platform until 70 hours after picking. The incoming apples ranged in temperature from 58° to 42° F. They required 12 hours after placement in cardboard packs to cool down from 58° to 38°, and a total of 60 hours to bring the core temperature down to 32°. The research shows that commercial apple growers can reduce storage losses by avoiding long delays between picking the crop and storing it under proper temperature conditions.

2,4-D valuable on citrus crops

A fungus-caused rot, called Alternaria rot, causes more California lemon fruits to decay than any other one fungus. The California station reports having achieved remarkable control of this type of lemon rot with the use of 2,4-D. Use of 2,4-D or of 2,4,5-T (2,4,5-trichlorophenoxyacetic acid) as a tree spray on lemons reduces mature fruit drop. It increases the yield by letting the lemons stay on the tree longer and grow larger. It also gives the fruit a longer storage life. In one experiment, use of 2,4-D spray on grapefruit increased the size of the grapefruit, resulting in a gain of $5 per tree. Research is still under way to learn whether use of these sprays for this purpose has any limitations that should be known before they are given widespread commercial application.

Quick chemical tests for fruit virus diseases

The Washington station reports a quick, simple chemical test whereby certain fruit tree virus diseases can be detected readily and quickly. This discovery is expected to be a big help in preventing the carriage of virus diseases via foundation stock to farm orchards. The station reports that the test has detected ring spot, mottle leaf, rasp leaf, rusty mottle, twisted leaf, "little cherry" diseases of sweet cherry trees, cherry rusty mottle, western X disease, and "little peach" diseases of peach trees.

In making the test, a disk is taken from the middle of the leaf with an ordinary paper punch. This disk is put in a test tube with a solution of sodium hydroxide, copper sulfate, and sodium citrate. The tube is then heated in a boiling water bath for 5 to 10 minutes, allowed to cool for 10 minutes, and then shaken thoroughly. Normal leaves give a blue-green color. Those from plants infected with certain virus diseases give a red color of varying hues. While the differences in color can be detected by eye alone, measurements are made in a photoelectric colorimeter. The chemical giving the color is believed to be tannin. Further

investigations are under way to determine the full scope of usefulness and the limitations of this method.

Virus diseases of stone fruits

A major problem facing growers of cherries, peaches, and other stone fruits is that of virus diseases. Experiment stations in the several regions are making plans to attack the problem on a regional basis. The Utah station demonstrated in the past year that the same virus that causes the western X disease of peaches and chokeberries also causes wilt and "little cherry" diseases of cherries. Utah workers found little cherry disease only on mazzard rootstock. Growers have been advised to plant mahaleb seedlings for rootstock and topwork these to the desired varieties. The western X virus does not appear to enter the mahaleb wood.

Cherry yellows and necrotic ring spot

For many years cherry yellows and necrotic ring spot had been cutting cherry yields in Door County, Wisconsin, the country's most concentrated sour cherry producing area. Cherry yellows usually reduces the yield of a tree to one-half or one-third normal after a few years' infection. Extensive experiments have now shown ways to produce cherry stocks free from the disease, by testing for its presence and propagating only disease-free material. Complicating the disease study and control are the facts that the means of transmission are not known, the relationship between the two diseases is not understood, and most nursery stock in the past has carried the diseases without showing them. The leaf symptoms of cherry yellows do not appear if night temperatures are higher than 61° F. Necrotic ring spot symptoms usually appear on a tree only one season, and then only in certain cases.

The nurseries supplying planting stock for Wisconsin cherry orchards are largely located in areas where young trees seldom or never show symptoms of the diseases. Wisconsin scientists have worked out two tests for the disease. The tests have been in use by the Wisconsin and Indiana experiment stations. Certain nurseries in Indiana, Missouri, and Iowa are now cooperating in propagating and supplying to Wisconsin orchardists stock free of these two virus diseases.

Basic research on peach brown rot

Peach brown rot causes one of the heaviest economic losses in eastern United States peach orchards. The extent of annual damage sustained by growers, shippers, processors, merchants, and consumers from this disease varies from season to season. In 1948 a 40-percent loss of midseason and late varieties resulted in the Maryland Eastern Shore peach area. Control to date depends on the thoroughness with which the orchardist prevents insect infestation and follows recommended sulfur applications. In many seasons, however, discouraging losses result in spite of the best efforts of growers. Wet weather and insect abundance permit brown rot to produce enormous wastage.

Orchardists and marketers have asked agricultural research workers to speed up basic research that would lead toward development of more effective methods for control of the disease. In the past year the Illinois station has made important findings that point to the direction that research must take to solve this problem for growers. It was shown

that peaches are apparently protected from infection by the fuzz on the surface of the peach. Preliminary tests showed the fuzz capable of either killing the brown rot spores or of preventing their germination. Attack by the brown rot spores was found possible as a rule only when the peach skin had been injured. Insects were found to be the most important causes of these skin injuries, confirming the idea that insect control is very important in preventing ports of entry for the brown rot spores into the fuit. The only material so far found that will prevent brown rot after the fungus is in contact with the flesh of the fruit is "copper 8-quinolinate," used with a new commercially available wetting agent.

Brown rot disease control in the package

The Delaware station found that spraying peaches with various fungicides during the preharvest and harvest period did little to control development of brown rot in peaches that are being marketed. This was particularly so for the later pickings. Delaware workers found that dipping the fruit in water-soluble liquid lime-sulfur (2 quarts to 100 gallons) reduced infection from 52 percent to 20 percent. This treatment did not affect appearance, odor, or taste. The liquid lime-sulfur, however, failed to control *Rhizopus* rot in the package. The latter could be controlled by refrigeration at 42° F. for 3 days, which also controls brown rot in the package.

Brown rot spores are spread in handling peaches and readily develop in injured fruit. The reason for this is that the spores of the fungus causing the rot are spread about in handling the peaches and readily start the process of decay whenever they enter a spot where the skin is broken. The Delaware station, therefore, made a study of methods of preventing injury to the fruit during picking and packing. The study showed that blemish-free peaches carefully packed in the orchard developed much less brown rot than peaches handled in the usual way. Peaches taken at random from pickers' baskets in the orchard showed 12 times as much rot and peaches taken at random after going through the cleaning process at the packing house showed 20 times as much rot as the blemish-free fruits carefully packed.

SMALL FRUITS

The small fruit growers, like the orchardists, look to station and departmental research for technical know-how. Consumers of berries and vine fruits insist on good flavor as well as appearance and there is an increasing demand for high vitamin C content and other nutritional qualities. These qualities vary inherently among fruits and varieties. Quick-freezing processes and other engineering innovations are changing the food habits of many people, which places new emphasis on types and varieties of fruit for various forms of processing. Station pomologists and plant breeders are doing their best to meet the problems of growers.

New berries for Tennessee

A good example of the work done by State experiment stations in developing varieties of berries and other small fruits best suited to local farming conditions is that of Tennessee. It is located in an inter-

mediate area to which neither truly southern nor northern varieties of small fruit are well adapted, but where there is, nevertheless, abundant suitable land for berries. The State experiment station recognized an opportunity to develop in the region varieties of strawberries, raspberries, and blackberries that would thrive and would provide a basis for a profitable berry industry. Furthermore, in the years since the breeding work began, methods developed for preserving these fruits through freezing, have tended to speed up the research. The Tennessee work in small fruit breeding has been highly successful. This is shown in the excellent varieties developed and distributed by the station in recent years.

Raspberries posed a particular challenge to station plant breeders because the well-known northern varieties, such as Cuthbert and Latham, did not thrive under the environmental conditions of Tennessee. Leaf spot diseases which defoliated the plants during the long summer months were a particular menace to northern varieties. In the Van Fleet variety, of Department origin, the Tennessee breeders found genetic characters of disease resistance and an adaptability for combining with other varieties. Van Fleet was itself a hybrid between an Asiatic species and the cultivated raspberry.

Tennessee Autumn Red

Several valuable raspberry varieties have emanated from the Tennessee breeding program, including Tennessee Autumn, Tennessee Luscious, and Tennessee Prolific. Together these provide a satisfactory list of varieties for the home garden and for commercial culture.

Increasing berry yields

An Ohio fruit grower had established a State-wide reputation for getting large yields of everbearing strawberries. He confided his methods to the Ohio station, which not only demonstrated the soundness of the principles employed by this grower, but also brought out that the secret of high continuous yields into the fall season lay in proper spacing. Over 8,000 quarts of berries per acre were obtained in the 1948 tests in which plants were set 1 foot apart in triple rows. Under the original system for growing everbearing strawberries, where the parent plants were spaced 18 inches apart and the runners allowed to form matted rows, the total yield was only 1,000 quarts. Although yields like those obtained in the 1948 experiment cannot always be had, growers with suitable land and available labor can raise excellent strawberry crops at a time when berries are scarce and prices at a premium.

Sawdust mulch steps up blueberry yields

In seeking the best cultural practices for highbush blueberry growing, the Rhode Island station found sawdust mulch better than straw mulch or clean cultivation plus cover crop, or clean cultivation throughout. In some years during which the experiments were made the use of sawdust mulch doubled the yield. The station found that the temperature of soil under mulches was more or less even. Temperatures under mulch in summer were considerably lower than air temperatures and showed very little fluctuation, while soil temperatures in clean-culti-

vated plots often came close to the air temperatures and showed very decided up-and-down changes.

VEGETABLE AND ORNAMENTAL PLANT RESEARCH

Commercial vegetable and flower seed and bulb growers and commercial nurseries annually perform an important service for millions of farmers and homeowners. Their services help to bring about volume increase of many new varieties of vegetable, flower, and ornamental plants. Behind the development of a new lettuce, gladiolus, or tomato variety, there usually is a long story of tireless research by numerous workers at State experiment stations and in the Department of Agriculture.

The modern tomato

An example of such research is the tomato. Comparison of currently appearing seed catalogs with those issued 10 and 15 years ago reveals a long list of new varieties that have almost entirely replaced the old.

In their constant and continuous world-wide search for new plant varieties, Department scientists found, in the highlands of Peru, the wild and hardy species of tomato known as *Lycopersicon pimpinellifolium*, with fruit no larger than a currant. From this stock, however, plant breeders in the Department and at cooperating experiment stations developed many crosses and hybrids that have in them the necessary genes to resist wilt and other tomato diseases. Parallel breeding work also considered such things as earlier maturing and adaptation to satisfactory greenhouse production for the early market and other features that meet special requirements of growers.

Increasing tomato size with hormone sprays

The hormone spray, *p*-chlorophenoxyacetic acid, is now widely used to increase fruit set, size, and yield of tomatoes. It was first fully developed by the Missouri station. It is used on greenhouse stock during the winter and in outdoor tomato culture during cool weather. The Missouri station reports that in tests made last year application of synthetic growth substances at full bloom to 4 days later resulted in striking increases in fruit set and size. Applications as early as 8 days before full bloom were harmful.

Better tomato pruning

The ultimate size of the tomato crop may be limited by the leaf area in relation to number of fruit set, and the amount of light received by the plant. The Missouri station has worked out a new pruning method that permits additional foliage for the plant. An axillary shoot is permitted to develop below each cluster but is pinched back, allowing two leaves to remain on the stub. As a result of this new method of pruning, yields of greenhouse tomatoes were increased 37 percent and of field-grown tomatoes 15 percent.

Vitamin and pigment studies of tomatoes

Commercial tomato varieties are widely accepted as a good source of vitamin C. Reports of pigment studies at the Indiana station reveal that the pro-vitamin A (beta-carotene) content of tomatoes may be increased more than 10 times the normal concentration. However, since

beta-carotene is an orange pigment, such high vitamin A tomatoes are orange in color.

Fortune tomato released in Arkansas

Disease-resistant tomatoes were the aims of an Arkansas tomato-improvement project begun in 1939. In 1948 the first new tomato variety developed under this program was released under the name of Fortune. This fruit is of dark-red color and excellent size, and the plants are resistant to fusarium wilt.

Under this project continued work was done on nematode resistance, which disclosed apparent variations in nematode strains. A number of tomato lines carrying resistance to the root knot nematode are being used. The breeding and selection are to continue, and a description of the Fortune variety will be given after the 1949 growing season.

Gas injurious to flowers

The New Jersey station has, within the past year, contributed further evidence that losses may be expected if ethylene gas is present in greenhouses where orchid flowers are being produced. This gas, which is a product of combustion in oil heaters and gasoline motors, is an insidious worker for in concentrations as low as one-tenth part per million it can ruin opening orchid flowers and make them totally unsalable. This same gas, ethylene, is given off by some fruits as they ripen, notably apples, and the New Jersey station reminds housewives that orchids, placed in a refrigerator with fruit, may be damaged as are flowers grown for commercial sale.

Mushrooms and cucurbits

A great variety of research like that carried on with tomatoes is also under way for other vegetables. The research divides itself into several major phases. Of immediate practical significance to growers is the breeding and introduction of adapted and disease-resistant varieties. Closely associated with this research is that dealing with improved production methods and insect and plant disease control. Other studies are directed at fundamental questions on the solution of which later applied research of great practical significance can be developed.

Mushroom yields respond to B-vitamin complex

A discovery of great potential significance for the mushroom-growing industry is contained in the Ohio station's report on a study dealing with nutritional requirements of the mushroom. Several commercial mushroom growers cooperated with the station in this research. The scientist in charge of the project found that adding water containing B vitamins singly or in combination to different plots in experimental mushroom beds stimulated mushroom growth. The beds were so managed as to be fertile and otherwise suitable for mushroom growing. In the best yielding plots, plants fed B vitamins grew as many as 90 mushrooms, with a total weight of 4½ pounds per square foot of bed. Studies are now under way to learn which amounts of the B-vitamin concentrations bring best results and at what time they should be applied.

New cucumber in Mississippi

The Mississippi station released in 1948 a new cucumber variety named Magnolia. It is dark green in color and especially attractive for pickling. In 3 years of testing it almost doubled the yield of standard pickle varieties in Mississippi. It is a cross between the National Pickling variety and an unnamed Puerto Rican hybrid.

The Miles, new wilt-resistant watermelon

The Tennessee station has carried on fundamental research dealing with fusarium wilts as these affect cotton, tomatoes, watermelons, and other plants. As a result, the station developed a new wilt-resistant watermelon known as Miles, announced in 1948. It is adapted to area in the State where watermelons could no longer be grown because of wilt.

Borer-resistant squashes

The New York State station tested 13 varieties of squash and pumpkin to learn whether any of them showed resistance to the troublesome squash borer. The tests revealed marked differences, apparently caused by the growth habits of the different sorts and the presence of substances unfavorable to the growth of the young borers in the tissues of certain strains.

Three trailing-vine varieties of the "pepo" species, Table Queen, Connecticut Field Pumpkin, and Small Sugar Pumpkin, although attractive to the female moths for egg laying, were moderately resistant to borers, as a result of the antibiotic effect of the plant tissues on borer growth. These varieties were also resistant to the spread of the stem rot organisms.

Research on vegetable diseases

Disease organisms may invade plants through air-borne spores. However, there are several other ways in which these organisms may attack. One medium of attack is through soil in which diseased crops have been grown. Another is through infested seed or rootstock or through implements used in tilling the soil. A third is through disease-carrying insects. Station research is directed at all three. Out of this research in recent years has developed the nematode hypothesis, which applies to all plant-disease studies.

Nematodes, or eelworms, are true worms, but of a different order from earthworms and similar segmented creatures. Those attacking plants, however, are very tiny, practically microscopic in size, the largest species being about 2 millimeters in length. Where they gain a foothold in plants, they not only cause direct damage but also become the advance agents for many plant diseases. They perforate plant rootlets with tiny punctures through which the disease organisms enter.

Nematocides tested by North Carolina station

The North Carolina station has given special attention to methods of eliminating nematodes. One type of nematode causes a disease popularly called root knot, which has become a major problem to be faced in growing summer vegetables in North Carolina, as in many other Southern States. The station tested six nematocides on the same plots for 6 years in succession. They gave good control but did not eliminate

the nematodes. There was no sign of cumulative injury to plants by the chemicals. Ethylene dibromide applied in the row 10 days before planting controlled nematodes and markedly increased yields of cantaloups. Uramon applied in the fall at ¼ to ½ pound per square yard increased markedly the yields of okra and tomatoes during the following spring. Cantaloups planted in 1948 on plots treated in 1946 with Uramon, chloropicrin, or D-D had less root knot and yielded better than those in untreated plots.

Plant disease control through chemotherapy

The application of the principle of chemotherapy in plants, now being made in a research project carried on at the Connecticut Agricultural Experiment Station,[7] is beginning to show considerable promise. Several years ago, scientists at the Wisconsin station found that protocatechuic acid, a compound in colored onions, gives the colored varieties resistance to smudge, a characteristic lacking in white onions. The Connecticut station has found that the X disease of peaches becomes less severe in trees that take up calcium chloride from the soil. The station has also perfected technical methods of screening chemical compounds in terms of their ability to counteract plant diseases inside the plant. These methods are being experimentally employed against fusarium wilt of tomatoes. Three compounds developed by the station have been shown to prevent fusarium infection in tomato plants when given at levels that will not cause direct injury.

Actidione found to control mildew

Mildew sometimes becomes a serious problem on plants growing in the greenhouse and, under certain weather conditions, on plants growing in the field. The Michigan station investigated the new antibiotic material known as actidione to learn what toxic effect, if any, it might have on plant tissue and seed. Actidione controlled mildew on both beans and roses under greenhouse conditions. The beans showed no signs of damage when the actidione was used at strengths that kill the mildew. Roses were, however, far more sensitive to the actidione, where injury appeared to vary according to variety, environmental conditions after spraying, and the age of foliage. The Michigan station cautions that before growers use actidione on a large scale they should await outcome of further research dealing with practical use of the material.

Aster yellows problem solved in Idaho

Idaho is one of the important vegetable seed-growing States. Recently this industry has been threatened by the insect-spread virus disease known as aster yellows which affects carrots, lettuce, and, to some extent, onions. Station scientists found that the most practical control measure was to break up the cycle of infection from the seed crop to the young seed-producing carrot plants. It had been common practice to grow the two together. This was changed to planting the steckling crop at a distance from any seed-producing field. Although

[7] Greater details on contributions which the Connecticut station is making to progress in chemo herapy for plants are contained in the report on the station's work with Dutch elm disease, p. 84.

aster yellows infection was as high as 20 percent in 1945, the 1948 survey showed none.

Disease control in carnation and gladiolus beds

Effect of gypsum on bacterial disease of carnations

Florists are not the only plant growers who may benefit by a discovery recently made by the Ohio station that an increasingly widespread loss-producing bacterial disease of carnations could be reduced in intensity by feeding the plants an adequate amount of calcium without getting the soil too alkaline. The calcium was applied in the form of calcium sulfate (gypsum) which does not decrease the acidity like some other forms of lime. This research opens up the possibility that resistance of various crop plants to certain other bacterial infections may be enhanced in the same way, a possibility that should be worthy of exploration by experiment station workers.

Hormone and chemical weed control

The Michigan station proved that 2,4–D, used as a pre-emergence spray, would serve as a protection for 3 or 4 years against weeds in gladiolus beds. The 2,4–D was applied immediately after setting the corms or within 10 days thereafter. Growers have widely adopted its use for weed-control purposes. Some of them have reported savings as high as $250 an acre compared with previous methods.

In a weed-control experiment carried on by the New Jersey station, various combinations of Fermate, as a seed, sprout, and plant-bed soil treatment, were used for the control of scurf. Of the treatments used, the soil treatment proved to be very effective in the control of this disease. In this experiment the soil treatment provided more protection against scurf than did the seed and sprout treatments combined.

INSECTS, INSECTICIDES, AND CONTROL EQUIPMENT

In addition to the research reported on flies and their control around dairy barns, and the control of crop and other insects referred to below, the following significant research in entomology was reported by experiment stations during the past year.

Beneficial insects and insect behavior

Unfortunately the word "insect" has become almost synonymous with the word "pest." All insects are by no means enemies of plants and man. Without a wide variety of insects, particularly many species of wild bees in addition to the domestic honeybee, the pollination and reproduction of much plant life would be under a serious handicap. Nature also has a tendency to establish competition among species. The antagonisms between certain species of insects have set up some natural balances without which insects might by now have inherited the earth. It is for the purpose of learning how some of these natural balances are established and to find controls for individual harmful species, that it is essential to carry on research on insect behavior. Besides the findings that certain squash vines resist borers (p. 92), that radiant energy will help trap corn borer moths (p. 56), and that

ultrasonics will kill insect (p. 102), the State experiment stations have made the following important discoveries about beneficial insects and insect behavior.

The role of bees in Ladino clover production

The Oregon station carried on experiments to learn the effects of keeping bees from Ladino clover. Seed production of the Ladino placed under a cage was compared with seed production in an adjoining plot not under a cage. Only 365 normal seeds were produced per 100 heads of the Ladino flower in the caged plot. This compared with 13,946 normal seeds grown per 100 heads in the uncaged adjoining plot.

The Oregon station also reports the experience of a farmer in the State who greatly increased Ladino seed yield and production by placing bee colonies in the fields. This was attributed to increase in the bee population to 3.6 bees per square yard of clover as compared with the Oregon average of 1 to 1½ bees per square yard.

Bee losses from use of insecticides

The Utah station tested the effect on honeybees of various chemical dusts used on flowering alfalfa. The insecticides used were 3-percent DDT, 5-percent chlordane, 1-percent parathion, and 10-percent toxaphene, and were applied during hours when bees were not visiting the flowers. Parathion killed about 40 percent of the visitors, DDT about 28 percent, and chlordane 23 percent. In the tests with parathion two-thirds of the bees died in the apiary, whereas two-thirds of the deaths from chlordane and most of them from DDT and toxaphene took place in the field. The results showed that dusting of flowering alfalfa over a considerable portion of the bee range during a honey flow may reduce the honey yield. If appreciable amounts of these insecticides remain on the alfalfa at harvest it should not be fed to milk cows or meat animals soon before slaughter for human consumption.

How much grass do grasshoppers eat?

The Wyoming station placed cages covering 1 yard of good grassland each and put into them 0, 15, 25, and 35 young grasshoppers to measure the amount of grass they would eat. This was done by measuring, at the end of the season, the grass left in the cages after clipping, drying, and weighing it. Converted into pounds of grass per acre, the land selected produced 1,200 pounds of grass. The feeding of the grasshoppers reduced the amounts of grass yielded in the respective cages as follows: 15 hoppers, 406 pounds per acre; 25 hoppers, 489 pounds per acre; and 35 hoppers, 792 pounds per acre. The experiment demonstrated that ranchers could save $4.60 per acre and more through buying grasshopper bait rather than native hay at $28 per ton to replace grass eaten by the hoppers.

Beach flies breed in decaying seaweed

A problem of beach-bathers along the ocean shore is to find relief from "beach flies." Of the four groups of blood-sucking flies, other than mosquitoes, found along the Jersey coast, the most important is the stablefly (*Stomoxys calcitrans*). The other three groups of bloodsuckers are the greenheads, deer flies, and biting midges. Entomologists of the New Jersey station have been studying practical means to control the

adult flies. Stableflies were found to remain in sheltered places for days at a time when the weather didn't suit them and then become active almost immediately when conditions changed.

Three years of observation have shown that *Stomoxys* breeding occurs in decaying seaweed on the bay shore. Disposal of seaweed washed ashore is impractical because it would cost too much. It was found that 90 to 95 percent of the adult flies emerging from the seaweed could be killed by applying an insecticide with a residual or lasting effect. In 1948 0.5-percent emulsions of DDT, DDD (which is also called TDE), and methoxychlor were used at the rate of 2 gallons per 100 square feet. They gave good kills of emerging flies. DDT was slightly superior and because it is cheapest appears most promising for large-scale use. A large-scale control experiment was conducted last summer at Seaside Heights, with good results.

Early shallow tillage controls wheat stem sawfly

The North Dakota station is studying the nature and behavior of the wheat stem sawfly and the effect of this insect's larvae activity on wheat yields. In both 1947 and 1948 the station found the sawflies to have decided preference for the more vigorous and high-yielding stems of wheat in its experimental plots. Attack by these flies result in shrinkage of the kernels and loss of weight. Based on a count of "fallen" and unrecovered heads caused by sawfly damage in the experimental plots, the station estimates that from 3 to 5 million bushels of wheat have been lost annually on North Dakota farms in the past 8 years. This is in addition to the "shrinkage" of kernels that are harvested. The station has not found practical ways of using insecticides for control. Early shallow tillage exposing stubble and roots of the previous harvest to weathering will destroy many overwintering sawfly larvae effectively. Early harvesting before storms knock infested stems over is at present the most practical means to avoid loss of wheat from fallen heads. The Rescue variety is the only commercial hard red spring wheat showing much resistance to sawfly.

Virus control for alfalfa caterpillar

The California station has found that a virus disease of the alfalfa caterpillar is an important factor in natural reduction of the population of this insect in California. The workers discovered that the virus could be produced in the laboratory and applied as a spray to cause infection in the insect. Through such a spray the virus epidemic among the caterpillars can be caused earlier than it would occur in nature thereby cutting down materially the amount of damage to the alfalfa crop. The station cautions that more tests with this virus spray are necessary before its potentialities and limitations are known and before it can be recommended for use.

Insect-borne plant diseases

Experiment stations contribute an increasing amount of knowledge annually to that already available about the spread of plant diseases by insects. In the case of a number of plant diseases, the simplest control method is to kill the insect carriers.

In addition to finding that DDT checks the elm bark beetles which spread Dutch elm disease (p. 84) and that proper spacing controls

aster yellow attacking carrots grown for seed in Idaho (p. 93), the State experiment stations have made further progress in research on the control of insect-borne plant diseases.

DDT reduces spread of potato leaf roll

The green peach aphid, *Myzus persicae,* is the principal carrier of the potato virus disease, leaf roll. A study conducted cooperatively by the Maine station and the Department revealed that use of DDT materially reduced the spread of leaf roll in plots of Green Mountain potatoes. This was attributed to a great reduction in the number of green peach aphids.

The New York (Cornell) station, over a 3-year period, found that where DDT was used, leaf roll did not increase and in some cases was reduced materially. DDT was found to be very effective for the control of peach aphids on potatoes. These were repelled by DDT coatings and would not feed on a DDT-sprayed leaf.

Although use of DDT is very helpful in preventing spread of the leaf-roll virus, the problem cannot be entirely controlled by use of DDT. Sprayed leaf surfaces are not repellent to the potato aphid, *Macrosiphum solanifolii.* These insects are, however, killed by short exposures to DDT residue. Weeding out diseased plants and using disease-free seed must be continued along with DDT spraying if leaf roll is to be effectively controlled.

Orchid mosaic virus transmitted via aphids

The Cattleya orchid is the most important of the orchids grown. One of the principal losses to commercial growers is through mosaic disease which causes breaking of color and malformation of flowers. In 1949 the California station succeeded in transmitting the virus responsible for this damage by green peach aphids that move from diseased flowers or buds to flower buds or very tender leaves of healthy plants. This was the first time that an orchid virus had ever been transmitted by insect experimentally. It was only the second instance on record of experimental transmission by any means of an orchid virus. The discovery indicates that the virus that spreads mosaic may be prevented by control of aphids, particularly during the flowering period of orchids grown in greenhouses.

Insecticides and methods of use

In the past few years many new insecticides have come into prominence. Although DDT now has some definite limitations as an insecticide, it still has wide practical use in controlling many kinds of insects. Experiment station research, in fact indicates that the insecticide can be increasingly useful in controlling insects where there is no danger of residuary contamination of a food product. Many of the stations also are testing the effectiveness and limitations of the newer insecticides and of methods for their application. *In the case of practically all these insecticides, the stations and the Department urge that extraordinary caution be practiced by the user.* While the newer materials are excellent insect killers, some of them can also kill human beings. Practically all of them can cause serious illness or discomfort.

Concentrated spray methods tested

The Wisconsin station carried on cooperative tests with the Department to learn what practical advantage aerosols, mist blowers, and reduced-gallonage spray applications offer. It was shown that under many conditions these new insect control application methods can save vegetable growers time and money spent in hauling more water than necessary over their fields. The tests have also shown that the most suitable application method may depend on such things as the particular material being applied, the crop, and the insect to be controlled. One finding of importance to growers is that often it is not necessary to buy an entirely new set of equipment for low-pressure, low-gallonage sprays. Reducing the operating pressure and changing disks and whirler plates will, in many cases at least, enable the grower to adapt high-pressure, high-gallonage equipment in making application with 50 percent less water.

Atmospheric conditions influence effectiveness of insecticides

Entomologists at the Texas station, in studying the effects of various insecticides on the cotton boll weevil, have found that temperature and humidity play an important part in the effectiveness of those materials. The organic insecticides became less effective at high temperatures, whereas calcium arsenate changed very little. However, when the humidity was also high, the toxicity of calcium arsenate was reduced. Twenty percent toxaphene was less affected by high temperature and high humidity than other organics. It is apparent that temperature and humidity should be taken into account when applying dusts or sprays in order to obtain the full effectiveness of the insecticides. Further studies will seek to determine the action of insecticides on the metabolism of insects.

DDT tests on cotton, tomatoes, and squash

The Louisiana station conducted tests on the use of DDT dust on cotton, melons, and certain vegetable crops. DDT in purified form was found safe and effective against pickleworms and melon worms when used on squash. DDT was also effective against thrips on seedling cotton and tomato fruitworm but when this insect went to work as the well-known earworm on corn, DDT dust proved ineffective.

Toxaphene dust effective against boll weevil

The Louisiana station found 20-percent toxaphene dust effective against boll weevil, bollworm, and thrips on cotton. Adding 40-percent sulfur to the toxaphene dust also gave control of the rapid and tarnished plant bugs. However, toxaphene was more destructive to beneficial insects on cotton than other materials tested.

Fall armyworm and lesser cornstalk borer control

In comparative tests of the newer insecticides, the Louisiana station found that the fall armyworm succumbs to 5-percent parathion, 3-percent gamma benzene hexachloride, and 10-percent DDT, thereby doubling corn yields. The lesser cornstalk borer, which also attacks sugarcane, was effectively controlled by soil treatments with parathion, chlordane, and toxaphene.

Cryolite and Ryania for sugarcane borer control

In an over-all project to study control of insects affecting sugarcane production, the Louisiana station found, after testing many new insecticides, that dusting with cryolite provided the most satisfactory control of sugarcane borer. Dusting with Ryania was the next best. Control of third-generation borers by dusting was accomplished for the first time.

In an experimental planting with seed cane having from 0 to 60 percent or more of the joints infested with borers, the yield of cane increased from about 11 tons for the heaviest infested cane to over 26 tons per acre for the lightest. In its annual spring survey the Louisiana station also found that the population of the first- and second-generation borers was so low that dusting was not necessary in the spring of 1949, which saved growers an estimated $60,000 or more in dusting costs.

BHC in soil and on corn and cowpeas

In tests made by the Louisiana station benzene hexachloride (BHC), used at rates as low as 2 ounces (gamma isomer) per acre, proved to be a useful soil poison against sand wireworm, seed-corn maggot, and southern corn rootworm. One application showed effects during the second year.

Rootworm control in peanuts

The southern corn rootworm has caused serious losses of field-cured peanuts on some Virginia farms. In tests made by the Virginia station with benzene hexachloride, chlordane, parathion, toxaphene, and DDT, broadcast as dust over the soil of small plots and raked in, the amount of pod injury by the rootworm was greatly reduced. The insecticides were also applied to the foliage in dust form. All gave good control of the southern corn rootworm, but the benzene hexachloride is reported also to have had some stimulating effect on the peanut plant. Some of the largest peanut yields ever produced were obtained by the use of benzene hexachloride. No off-flavor was detectable in the unprocessed nuts where BHC had been used. Preliminary tests on the effect of BHC as a soil treatment on peanuts after processing gave negative results.

Bean weevils succumb to fresh black pepper

Small quantities of dried beans can be protected from bean weevils. The Maine station, in a test of several methods, found that ½ teaspoonful of black pepper fresh from the store, per pint of beans, gave a high degree of protection from bean weevils in beans exposed to severe infestation.

Parathion protects tobacco

The Connecticut Agricultural Experiment station, on the basis of recent observations in its research dealing with tobacco aphid control, cautions that use of DDT on potatoes may be responsible for driving aphids from potato to tobacco fields. Growers who found this to be true got relief from the aphids in the tobacco fields by spraying 0.2 pound of parathion per acre applied by either airplane or mist blower.

Pecan weevil controlled with DDT

The principal insect pest in pecan orchards of the South is the pecan weevil. The Oklahoma station carried on experiments which show that one application of DDT spray can mean a difference between a 5-percent crop and a 90- to 95-percent crop. Dry soil conditions were found to influence the time when the weevils appear. In Oklahoma peak emergence may come in August or September. Among control methods tested by the station, two and three applications of DDT gave the best results. One application properly timed gave 90- to 95-percent control. Arsenate of lead gave about 50-percent control. The old method of jarring trees rated poor. The station also tried soil fumigation to get at the weevil larvae under the trees. Ethylene dibromide and propylene dichloride, injected 6 inches deep, proved very effective. Chlordane and benzene hexachloride showed promise.

Trials in three pecan groves conducted by the Georgia station likewise pointed to DDT as an effective control against the pecan weevil. The DDT also reduced shuckworm infestation. The Georgia station recommends a spray schedule of two applications of 6 pounds of 50-percent wettable DDT in 100 gallons of water. This gave 95-percent control in one grove and 99-percent in another. A third grove sprayed with 4 pounds of 50-percent wettable DDT showed a lower percentage of control.

DDT best all-around potato insect control measure

In a comprehensive project dealing with the ecology, life history, and control of potato insects the Minnesota station demonstrated that DDT 5-percent dust was the best all-around potato insecticide. When potato flea beetles were counted on the third day following application, the DDT was well ahead of other insecticides tested. Similarly, DDT controlled potato leafhoppers as well or better. Parathion and benzene hexachloride were more effective against aphids, but the difference in results between these and DDT was not great enough to offset the value of DDT against the leafhoppers and flea beetles. For control of the six-spotted leafhopper, a mixture of 5-percent DDT and 2-percent parathion was most effective. On the basis of the Minnesota study potato-spraying schedules in the State have been revised and are believed to have contributed materially to increased per-acre yields in Minnesota, which have been doubled in some instances.

DDT and DDD tested at North Dakota station

The North Dakota station has found that DDT and other residual insecticides increase potato yields. Trials at the North Dakota station showed increases from 20 to 23 bushels per acre over those plots receiving no treatment except fungicides. The station also found that for the third successive year DDD (TDE) treatments have been among the highest yielding. When this new insecticide is produced in greater quantity with corresponding decrease in cost, it may become an important control measure.

DDD destroys larvae of red-banded leaf roller

Virginia fruit growers recently made savings conservatively estimated at $800,000 a year as a result of experiments being carried on by the Virginia station to find substitutes for lead arsenate in the control

of the red-banded leaf roller larvae and other orchard pests. Laboratory and orchard tests are being made with DDT, methoxychlor, ditolyl trichloro-ethane, Ryania, DDD, parathion, chlordane, and toxaphene. During the past year these studies showed that there was a marked increase of the red-banded leaf roller whenever DDT was used in the cover spray. The station likewise showed that DDD at the rate of 1 quart of 25-percent liquid, or 1¼ pounds of the 50-percent wettable powder per 100 gallons of water destroyed successfully most of the larvae of this pest. In addition to being such a sure killer, DDD is only one-tenth as toxic as DDT.

Residual and flavor characteristics of new insecticides

Whenever a new insecticide is developed, experiment stations and the Department urge the greatest caution in its use until all limitations are tested and the public has been advised regarding them. Not only does this apply to protection against personal hazard by the farmer and other handlers of the insecticide but to dangers from residue that may stick to fruits, cereal and forage crops, and vegetables, or that may be incorporated in animal or plant products. Unless this is done there is always the danger of injurious effects on the consumers. Experiments to determine the effects of insecticide residues are, therefore, most essential as a safety measure for the public. In addition to determining that arsenic residues resulting from orchard sprays may make soils unfit for growing some crops, the experiment stations made other advances in our knowledge of insecticide residues or the absence of them.

Parathion residues at harvest

Parathion residues at harvesttime were found by the New Jersey station to be generally very low on all crops tested. This was true regardless of the way in which the parathion had been applied. Parathion residues on plants decompose rapidly during the drying process prior to chemical analysis. The New Jersey station found that, for chemical determination of accurate values of parathion, the plants should be analyzed soon after harvest when fresh. Potato tubers from soil treated with 10 or 20 pounds of parathion per acre contained small quantities of parathion when analyzed soon after they were dug. Negligible quantities of parathion were recovered from corn kernels and shelled peas.

Elimination of toxaphene by cattle, sheep, and hogs

Toxaphene, a chlorinated camphene insecticide, has been proved useful for grasshopper control in alfalfa fields. The Montana station, with the cooperation of the Department and the manufacturers of this chemical, made a study of the extents to which its residue would be carried into the meat of cattle and sheep fed alfalfa hay from treated fields. In this experiment steers and lambs were winter-fattened on such hay. Following slaughter, it was found that even in those animals getting alfalfa treated with the maximum amount, any toxaphene stored in the fat had been eliminated within 11 weeks.

Residual flavor and odor of BHC

The New Jersey station reports that refined and pure grades of benzene hexachloride (BHC) in soil result in the development of off-flavored potatoes. The off-flavor is not so pronounced as that which results

when a technical grade of BHC is used. The latter persists in the soil from one year to the next, although it is less pronounced during the second year.

The Idaho station conducted tests to determine whether the meat or lard of hogs treated with BHC as an insecticide and miticide would become unpalatable. One group of animals was thoroughly sprayed with a water-suspension spray containing 20 pounds of 10-percent gamma isomer BHC wettable powder in 100 gallons of water. Another group was left unsprayed and used as a check. Animals were butchered 2 weeks following treatment and at 2-week intervals thereafter. No off-odor or taste could be detected in the cooked meat and rendered lard of the treated animals.

The effect of BHC used as a spray in peach orchards was studied by the Massachusetts station. Its report is that the spray may cause an off-flavor in canned peaches. Although a definite off-flavor from BHC may not be detected in fresh or frozen peaches, it may become very marked in the canned or heated fruit. Fruit growers in Massachusetts were warned that peaches sprayed with this material may become inedible when canned.

High-frequency sound waves kill insects

Another branch of physics research—ultrasonics—is about to yield profitable results. A number of stations and the Department are engaged in extensive research in various phases of ultrasonics. For instance, the Pennsylvania station found that high-frequency sound waves will quickly destroy mosquito larvae in a jar of water. Such waves are known to have a killing effect on many insects. They are being studied from the standpoint of their possible use to kill insect life responsible for fruit spoilage such as maggots in fruit being readied for shipment over long distances.

Rodenticides

New rodenticide thins blood faster than dicoumarol

The Wisconsin station announced development of Compound 42. Its immediate practical use is in killing rats and other rodents. But it represents an entirely new method. Chemically this new material is related to, but not the same as, dicoumarol, the blood anticoagulant discovered at the Wisconsin station a decade ago in connection with studies on sweetclover poisoning in livestock. Dicoumarol has now come into world-wide use to prevent coronary thrombosis and post-operative blood clots.

Working much faster than dicoumarol, Compound 42 is tasteless and odorless, and hence does not arouse the suspicion of the rodents. There is no violent body reaction. The animals die quietly after a few days, from internal bleeding. Only about a tenth of a milligram, an extremely small amount, is required to kill a wild rat. The bait is mixed at low concentration (1 : 10,000), and the rodents die after consuming the bait over a period of a few days. Tests indicate that chickens are much more tolerant to Compound 42 than rodents, and hence are not likely to be injured if they accidentally consume a moderate amount of the bait. Fortunately, there is a very effective antidote available if it should

be needed by either human beings or farm animals. Massive doses of vitamin K are highly successful in offsetting the effects of the new rodenticide.

Compound 42, like all rodenticides, should be handled with caution.

Rats and other rodents cause losses of hundreds of millions of dollars annually. Compound 42 gives promise of being the most useful material now available in mankind's fight to prevent these losses.

SOIL AND FERTILIZER RESEARCH

All farm production is directly related to the soil. For this reason the farmer must be concerned with the results of soils research regardless of what he produces. Today most research in soils is directed toward conserving soil and water, increasing fertility, and reducing per-unit production costs. Since soil is our greatest natural resource, and farmers' greatest asset, it is imperative that soil scientists strive to develop better methods of maintaining soil productivity and reducing costs, and that farmers acquaint themselves with new soil and fertilizer research information as it becomes available.

Fertilizers and lime

A potential saving of $800,000 a year can be made by Louisiana farmers if they follow experiment station recommendations concerning liming of acid soils that possess high phosphate-fixing capacities. About one million such crop-acres occur in Louisiana. The Louisiana station showed that applying dolomitic limestone on such soils increased yields of seed cotton. At pH 5.4 the yield was 203 pounds of seed cotton per acre, and at pH 6.5 it was 778 pounds per acre. When lime was used in addition to a complete fertilizer, the yield was increased from 1,500 to 2,018 pounds of seed cotton per acre. Liming increased the availability of native soil phosphorus more than that of the applied phosphorus. The use of dolomitic limestone along with complete fertilizer on Oliver silt loam reduced the fertilizer requirement of cotton by the equivalent of 120 pounds per acre of superphosphate. The station estimates that proper liming on such soils reduces the cost of phosphate fertilizer by 50 percent. Corn benefited from the increased phosphorus availability brought about by liming, but not so much as cotton.

Although Virginia farmers spent an estimated 10½ million dollars in 1948 for phosphatic fertilizers, only about 10 percent of the phosphorus applied was utilized by plants. The Virginia station found that careful appraisal of the soil type, and its lime needs, is a prerequisite to intelligent fertilizer application. Experiments covering a 4-year period showed that lime generally increased the amount of available soil phosphorus. The four soil types studied differed widely in their response to applied phosphorus. This varied response appeared to be associated with the acidity of the soil and the percentage saturation of the anion exchange complex and indicates that proper soil pH and partial saturation of the anion exchange capacity will improve phosphorus efficiency. If farmers could obtain increased utilization of native soil phosphorus and improved availability of fertilizer phosphates, a very large monetary saving would result.

Nitrogen fertilization experiments conducted by the Maine station in Aroostook County showed that increased potato yields were usually

obtained when 150 pounds per acre of nitrogen were applied in comparison with smaller amounts. This response was greater when potatoes followed potatoes rather than green manure crops. Increasing potash from 180 pounds per acre to 240 pounds gave no appreciable increase in yield on the soils studied.

Tests at the Utah station showed that yields of dry-land wheat can be increased 5 to 10 bushels on the average and that protein content of the grain can be increased 1 to 3 percent by the use of nitrogen fertilizer. In some instances yields were increased as much as 20 bushels. Early spring applications gave the greatest increases in yield.

In fertilizer tests made by the Iowa station, 60 pounds of nitrogen gave 211 pounds more bromegrass seed than the check plot, while 180 pounds of nitrogen gave an increase of 418 pounds over the yield of the check plot. Phosphorus increased yield only when 120 pounds or more of nitrogen per acre were used.

The nitrogen requirements of corn can be met with one application of nitrogen side-dressing on every soil tested so far, according to results obtained by the North Carolina station and the Department. This side-dressing is in addition to the nitrogen applied under the crop at planting time. The same amount of nitrogen, whether in the form of nitrate of soda, ammonium nitrate, or other nitrogenous material, gave about 30 bushels more of corn per acre when put on as a side-dressing when the corn was knee high than when the corn was in the early-tassel stage or when two or more side-dressings were given at different stages of growth. Combined with the use of adapted hybrids and good farm practices, proper fertilization is bringing bumper corn crops to southern farms. Similar results are reported from Arkansas, Mississippi, and other Southern States.

Trace elements and magnesium

Soil and plant scientists at 24 experiment stations are conducting important research on the relation of trace elements to soil productivity and plant nutrition.

The Missouri station found that certain essential amino acids are increased in alfalfa by field treatments with manganese alone, boron alone, and by the combination of manganese, boron, copper, zinc, and cobalt.

Extensive trace-element research was conducted by the New Jersey station. The manganese-supplying power of 25 important soils was determined and it was found that the need for manganese applications in the field was reduced by maintaining soils at pH 6.0 to 6.5. A new method of determining magnesium was developed and the critical magnesium level in 5 crop plants was established. Magnesium needs were best met by using fertilizers containing the equivalent of 2 percent magnesium oxide in a soluble form. Where dolomitic limestone can be used there is no need for further magnesium additions the second year. Molybdenum was studied in soils and plants for a possible relationship to X-disease in cattle. Apparently there was a relation between the copper present in the soil and the availability of molybdenum to plants and to its toxicity to animals. Laboratory experiments showed that a small quantity of boron may be adequate for plants growing on soil with low nutrient levels of nitrate and phosphate, but may be a seriously limiting factor when the nitrate and phosphate levels are increased.

South Carolina workers found rasorite to be a more available source of boron for corn on Norfolk sandy loam soil than colemanite. Corn plants took up less boron when it was applied before planting them when applied as a side-dressing. Similar results were obtained with turnips at four different lime levels on Cecil sandy loam. The level of liming did not affect the total amount of boron absorbed, although deficiency symptoms appeared at the high rates of liming, indicating that the calcium-boron ratio in the plant is very important.

Acid mineral soils often contain relatively large quantities of soluble manganese, aluminum, and iron. The New York (Cornell) station found that the increased legume growth that always results from liming such soils is due to the decreased availability of these elements rather than to a higher pH or an increased amount of available calcium per se.

Extreme caution should be exercised in the use of boron on potato fertilizers where potatoes are grown continuously or in a 2-year rotation involving potatoes and green manure. This advice is forthcoming from the New Hampshire station on the basis of experiments in northern New Hampshire. These also showed that there is a high economic return from the use of magnesium in potato fertilizer.

An experiment dealing with the relation of certain soil factors to the cooking qualities of potatoes, conducted by the Iowa station, showed that the specific gravity of the potatoes was not affected by soil treatments with sulfur and the minor element or by spray applications of manganese with zinc.

The Iowa station also engaged in extensive studies of injuries resulting from too much manganese when used on different legumes grown in cultural solutions. Relative sensitivity of five legumes to soluble manganese was in the following order: Lespedeza, sweetclover, soybeans and cowpeas, and peanuts. Lespedeza and cowpeas absorbed the largest amount of manganese, and peanuts and sweetclover the least. Symptoms of suffering from too much manganese differed greatly. In peanuts and sweetclover the leaf margins became chlorotic. This also happened in the case of lespedeza plus a spotting of the leaves. In soybeans and cowpeas irregular pale-green areas developed between the main veins. In soybeans and cowpeas tiny purple-red spots appeared over the entire leaf.

In Florida station experiments on Arredonda loamy fine sand, 10 pounds per acre of copper chloride gave large yield increases of oats, wheat, barley, and corn, but not rye. With peanuts this treatment produced much greater yields of both foliage and nuts and improved the grade of the peanuts.

A survey of the cobalt content of Hawaiian soils and forage crops shows a range of 5 to 156 parts per million of cobalt in the soils, and of 0.3 to 7.5 in the plants. The latter range is considerably above the value of 0.09 part per million necessary for the normal health of range livestock. The Hawaii station also studied the molybdenum content of typical Hawaiian vegetation. An increase of 10 to 15 percent in growth was obtained from molybdenum applications in a few instances.

The Louisiana station found that boron in addition to an 8-8-8 fertilizer and dolomitic limestone gave highly significant yields of seed cotton on Ruston loamy fine sand. Zinc, copper, manganese, boron, and iron, in combination, increased yields only when sulfur was also

applied. Sulfur plus dolomitic limestone and 8-8-8 fertilizer gave highly significant yield increases.

Soil physics, chemistry, and mineralogy

Scientific progress is rapidly changing research methods for solution of farmers' soil problems. New devices have speeded up examination and analysis of soil and plant samples. New techniques employing radioactive elements, the spectrograph, the Geiger counter-X-ray spectrometer, the flame-spectrophotometer, and the electron microscope have provided new and more rapid means of attacking soils and plant-research problems. Soil scientists are increasingly engaging in physical, chemical, and mineralogical research. The following results reported in the past year represent distinct steps ahead in soil knowledge.

A number of stations, including Pennsylvania, Connecticut State, and Wisconsin, have done outstanding research in the spectrometric examination of soil minerals. The Pennsylvania station has contributed a method for producing X-ray diffraction patterns of the sand, silt, and clay fractions of a soil on one piece of recording paper, for comparison with standard mineral patterns. This improvement in procedures has greatly speeded the X-ray analysis of soils.

X-ray analysis of basic soil minerals is being more and more widely used by scientists. This technique is practical in tests made to obtain extensive inventories of mineral particles in major soil types. Knowing the important minerals present in soils and their characteristics will enable the research worker to explain certain fundamental physical and chemical processes governing nutrient availability that have heretofore been unexplainable.

Radioactive phosphorus experiments have been conducted by the Alabama, Arizona, Colorado, Florida, Georgia, Idaho, Indiana, Iowa, Mississippi, New York (Cornell), North Carolina, Ohio, South Carolina, Texas, and Wisconsin stations, and the Department. These experiments have shown a wide range with respect to the amount of phosphorus taken from the fertilizer in comparison with that taken from the soil by different crops at various stages of growth. At the final sampling in experiments conducted on three different North Carolina soils, cotton grown on the least fertile soil took 30 percent of its phosphorus from the fertilizer, in contrast to only 7 percent taken by cotton on the most fertile soil. The use of the new radioactive tracer methods in soil and fertilizer research promises to lead to a more efficient use of fertilizer and a better and more scientific use of the soil resources.

The ability of air in the soil to circulate and to reach the root systems of crops is as important for good yields as is ample moisture. The Ohio station has recently reported the results of a long-time study which showed that the deterioration of the desirable crumb structure of soils caused reduced yields. Structural deterioration decreases the air space in soils with the result that oxygen may be too limiting for normal root and plant growth. On a silt loam soil potatoes did best when the air-supplying space was 50 percent or more of the soil volume. A period of 10 years in sod was required to restore good porosity and air-supplying capacity to soils adversely affected by continuous cropping. Liberal manuring from year to year was not enough to maintain suitable soil structure under continuous cropping.

The Michigan station has developed a rapid and practical moisture meter that will be of use to farmers and others in determining when to irrigate. The depth to which the applied water has penetrated the soil can be followed and the device set so that the application of water will be stopped when the desired moisture content is reached. This moisture meter employs nylon electrical-resistance units which make more accurate readings at higher moisture levels than were possible with the gypsum blocks formerly used. The nylon unit is also more satisfactory than the Fiberglass unit previously developed.

Soil conservation and management

The most important management problem on every farm is to decide how to put the particular land and water resources to best use for profitable yields and proper soil and water conservation. The Illinois station, cooperating with the Department in a study of the long-time farm income advantages obtained by farmers from the use of a complete soil and water conservation program, found an average advantage of $5.24 per acre per year for the central, northwestern, and southwestern Illinois areas. A complete conservation program on the 2,000,000 acres of slowly permeable soils in northeastern Illinois would have resulted in over $21,000,000 more annual net farm income. Capital requirements for initiating and establishing such a program would have totaled $68,000,000. Since the annual expected return would be slightly more than 30 percent of the initial cost, this would be considered a good investment in any business, whether in agriculture or in industry. Further research should provide means of securing even greater returns on such investments.

Many thousands of acres of land in the Southeast are too poorly drained to be well suited to farming. The North Carolina station, in cooperation with the Department, conducted experiments on these soils and found that drainage greatly improved both the porosity and biological activity as well as yields. The improved porosity was due to better aggregation of soil particles. It is estimated that drainage of the poorly drained, low-yielding land now under cultivation would increase farm income in North Carolina 10 to 20 million dollars. In addition, many more acres could profitably be put to agricultural use through drainage.

Rotation experiments carried out by the Kansas station have resulted in greatly improved yields due to legumes. In a rotation of corn, oats, wheat, and 2 years of sweetclover, corn yields were 20 to 40 bushels greater; oats, 10 to 25 bushels; and wheat, 5 to 25 bushels per acre greater than in a similar rotation without a legume.

Experiments by the New Jersey station, in cooperation with the Department, show the importance of rotations and organic matter in maintaining good physical condition of Coastal Plain soils. Tomatoes and sweet corn in 3-year rotations including clover sod, produced 18 tons and 10,000 ears, respectively, but when grown in rotation with clean cultivated crops, yields were only 11.9 tons of tomatoes and 4,490 ears of sweet corn.

Recent data obtained at the Connecticut Agricultural Experiment Station point to the continued importance of organic material in crop production. As much as a 41-percent increase in yield of sweet corn

was obtained when barnyard manure and commercial fertilizer had been applied in comparison with commercial fertilizer alone. All crops did not respond alike to organic materials. Carrots receiving the same treatment yielded only 6 percent more. Native peat applied under similar conditions gave a 20-percent increased yield for cabbages. The nature of the organic material and the soil are factors to be considered in appraising the value of organic matter in the production of any given crop.

Farmers have for generations recognized the importance of soil moisture in producing good crops. The Maryland station has conducted experiments that show definitely that most of the soil moisture is lost through evaporation from the soil surface. Measurements made in the soil down to 18 inches revealed that the moisture content of the soil is in direct proportion to the height and density of the vegetation growing on it.

The Maryland experiments, of course, refer only to the loss of soil moisture from the surface of the soil by evaporation and not to surface runoff. When heavy rains occur on saturated soils a greater part of the surface water may be lost as runoff especially on sloping fields lacking in good vegetative cover.

The Indiana station found that intensive cultivation was not necessary in southern Indiana peach orchards and that sod culture, when supplemented with mulches of hay and straw beneath the trees, was a good practice. Soil erosion was thereby reduced to a minimum and the chemical and physical condition of the soil maintained, thus making it possible to grow peaches on rolling areas without unfavorable effects on the soil. The station also learned that, in northern Indiana, on Coloma loamy fine sand, a mulch of manure, soybean hay, or straw increased the availability of soil potassium and corrected potassium starvation of young peach trees, as did applications of muriate of potash.

A laboratory study of common soil micro-organisms conducted at the Idaho station revealed that molds, actinomycetes, and bacteria, including the symbiotic nitrogen fixers, were capable of growth in cultures containing 2,4-D in excess of that which might be added to the soil in practice. The general microbiological population was not affected. Where legumes were seeded in soils containing 0, 1, 3, and 6 pounds of 2,4-D per acre, nodulation of the legumes was apparently not affected by the highest concentration, although legume growth was reduced by the 6-pound application.

HOME ECONOMICS RESEARCH

Home economics, like agriculture, is concerned, not with a single subject but with many scientific fields. Researches toward improving human nutrition, evaluating the composition and nutritive value of foods, and solving problems on food preparation and preservation, are pertinent to the task of keeping the family well fed. Other researches that have particular bearing on the home include those concerned with family living, home-management practices, and housing. The scope of home economics research at the State experiment stations is reflected in the following reports on accomplishments during the past year.

Nutrition

Nutrition research at the stations reflects the present trend toward precise investigations on such problems as determining the body's daily requirement for specific nutrients, determining how effectively the body utilizes a given nutrient from different food sources, or evaluating the role and the interrelationships of nutrients in the body.

Dietary iron requirements of women and adolescent girls

The recommended dietary allowances formulated by the Food and Nutrition Board, National Research Council, and most recently revised in 1948 were based on such information as was available at that time. It was recognized that the allowances would either be substantiated or revised on the basis of needed additional research on the dietary requirements of human subjects. Recent studies of the New York (Cornell) station to determine the dietary iron requirements of women and adolescent girls are, therefore, most timely, particularly in the case of the adolescents for whom prior data on this point were completely lacking.

The studies were conducted by the balance technique on healthy subjects maintained on a basal diet supplying iron from a variety of natural foods. The results led to the conclusion that 12 milligrams of iron is a satisfactory dietary allowance for women, although many women do not need that much. The analyses showed that 12 to 13 milligrams of iron are sufficient to cover the needs of adolescent girls. This is less than the amount tentatively recommended by the National Research Council. Preliminary work in the course of this investigation showed that beef is of special value in the diet because it improves the absorption of iron.

Adequate dietary calcium required in old age

A study of the nutritional behavior of laboratory animals is commonly undertaken to obtain valuable leads concerning human dietary requirements. Such a study was the one made at the New York (Cornell) station to determine the calcium utilization of rats. Young rats, starting at 38 days of age, stored 90 percent of the calcium from a daily diet containing 0.3 percent of calcium until they were 110 days old. At the age of 160 days, they were storing only 55 to 65 percent of the dietary calcium. When the rats were old, i. e., about 600 days of age, which is comparable to 60 years for a man, they were still storing calcium, since the amount in the dietary could not be lowered much below the 0.3-percent level, without the animal losing more calcium in its excreta than it consumed in its food.

The above experiments may be interpreted to mean that calcium needs are greatest in the growing animal, but that they are still significant in adulthood and the late years of life. Since all but a very small part of the calcium in the body of an animal is in its bones, loss of this element from the body means loss from the bones. In fact, the observed fragility and ease of breaking of the bones of old dogs that had not had enough calcium in their food suggests the need of adequate calcium in the diet in old age to maintain strong bones.

Availability of carotene in cantaloups

The principal source of vitamin A in the American diet is the carotene in plants. Cantaloup is an excellent source of carotene and an

important crop in Arizona. Recent work by the Arizona station has shown, however, that carotene content is not necessarily a measure of vitamin A activity because the physiological availability of the carotene to the animal varies in different plants. In experiments utilizing the white rat as a test animal, it was found that the carotene in cantaloup is approximately two times more available than it is in alfalfa and spinach, three times more than it is in carrots, and five times more than it is in apricots, sweetpotatoes, and turnip greens.

The Arizona station also undertook to chemically characterize this carotene fraction in order to learn why the carotene in cantaloups is so readily available. Spectrophotometric and chromatographic analyses showed the presence of only two carotenes in the varieties and strains of cantaloups analyzed. One of these carotenes was beta-carotene. The other was an unidentified carotene which was present in quantities varying from small amounts up to 60 percent of the total carotene content.

Utilization of the carotenoids in the papaya

Since good sources of vitamin A, such as liver, milk, and eggs, are not always economically available to all groups, the Hawaii station considered it important to investigate the utilization by humans of the plant pigments that can serve as precursors of vitamin A. The human utilization of cryptoxanthin, which constitutes the principal pigment of papaya, was of special interest. In the controlled 28-day dietary study conducted, sufficient papaya was fed to the subject to provide 3 500 International Units of vitamin A activity per day in the form of carotenoids. The blood levels of carotene and vitamin A maintained by the subject showed that the papaya cryptoxanthin could be converted by the body to meet its vitamin A needs. It was calculated that cryptoxanthin contributed 80 percent of the estimated vitamin A activity of the papaya samples used.

Nutritional interrelationships of thiamine and fat

To clarify the probable interrelationship of the thiamine and fat intake of the rat, studies were designed by workers at the Pennsylvania station to determine the thiamine and fat stored in the bodies of rats receiving regulated intakes of isocaloric diets. The results obtained are interpreted to indicate that thiamine does not increase fat deposition in the rat.

The composition of foods

Studies on the composition of foods are continuing. This research has three major objectives. One is to characterize those foods for which data are still meager. Another is to re-evaluate foods with some of the newer analytical techniques now available and in the light of the changing emphasis on human nutrition. A third and currently important objective is to determine how the composition of foods is affected by the many factors in operation from cultivation in the field to the final serving in cooked form. Of the many studies in this area, a few may be cited as illustrative of this research.

Vitamins in walnut meats

Nuts, because of their high fat and protein content and possibly the presence of other constituents, have offered difficulties in assays

to determine the vitamin content. As a consequence, vitamin data on nuts are meager. The data obtained by the California station on walnut meats are, therefore, timely. The analyses were not accomplished, however, without several years of preliminary work to overcome the analytical difficulties and to validate the rapidly developing chemical, physical, microbiological, and biological procedures. California-grown walnuts of three varieties for the same groves for four successive years were analyzed.

The results, expressed in milligrams percent, may be summarized as follows: Walnuts contain about the same amount of thiamine as whole-grain cereals, most lean meat, liver, egg yolk, and dried legumes —all of which are good sources of thiamine. As a source of riboflavin, walnuts may be classed with whole grains, lean meats, and certain vegetables in the middle and upper range of riboflavin content, such as cauliflower, broccoli, and most greens. As a source of niacin, walnuts are comparable to the few vegetables in the high range of niacin content and superior to all other fresh vegetables and fruits, milk, and eggs. They are not equal to the whole grains, dried legumes, fresh meats, and fish in this regard.

The amino acid composition of meat

Advances in nutrition research indicate that the requirement for protein in human and animal nutrition is essentially a composite requirement for each of a number of different kinds of amino acids. It has become necessary, therefore, to supplement data on the percentage of protein in foods with figures for the percentages of specific amino acids. Methods for amino acid determinations have been developed to the point where such analyses can be made, even though subsequent improvements in methodology may necessitate rechecking present values.

In an extensive study undertaken by the Texas station, the 10 amino acids that are considered essential for human beings were determined by microbiological techniques for 19 different kinds of meat, including various tissues from beef, pork, and lamb. Thirty other foods were analyzed for these same 10 amino acids, namely, arginine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine. For the same cut of meat there was little variation between animals in amino acid content and tissue of a given type was nearly the same whether it came from beef, pork, or lamb; histidine in muscle tissues was a notable exception. Meat was found to be a good source of all of the amino acids studied, and, as compared with grains and vegetables, an outstanding source of lysine.

The amino acid content of processed chicken meat products

The 10 essential amino acids, with the exception of methionine, were also determined in experimental packs of fresh and of cured smoked chicken processed by commercial methods at the Massachusetts station. Comparison of these data with figures on control samples of the fresh chicken showed that there was little destruction of the amino acids during commercial processing of chicken meat products. Only tryptophan showed significant losses, as much as 50 percent of it being lost in canning.

Amino acids in vegetables

Since little information is available on the amino acids in vegetables, the Arizona station studied freshly harvested broccoli, cauliflower, carrots, and sweet corn for their content of the 10 essential amino acids. Microbiological assay methods were used. The protein of cauliflower, as compared with egg protein, was fairly well balanced in amino acid make-up, although definitely optimum in methionine, valine, threonine, histidine, tryptophan, and possibly arginine and phenylalanine. The sweet corn protein was approximately optimum, as compared with egg protein, in histidine, leucine, phenylalanine, and valine; and broccoli protein, in arginine and methionine. Carrot protein was deficient in all the essential amino acids.

Folic acid in vegetables and plant materials

Although folic acid values for foods have been reported since 1942, improvements in the assay method, made possible by the use of a superior enzyme (hog kidney conjugase) for liberating the vitamin from the tissues, suggested the desirability of new analyses. These were undertaken by the Wisconsin station, which reports values for several fresh vegetables, canned vegetables, grains, and breakfast cereals. Large variations in the folic acid content of various parts of plants were observed. Fresh vegetables stored at room temperature suffered large losses of folic acid; these losses were largely checked by storage in a refrigerator, or even more completely checked by storage in ice. The data accumulated indicated that there might be "bound" forms of folic acid in plant tissues, not accounted for by the present improved method of analysis.

Retention of B-vitamins in cooked pork sausage and bacon

The effects of cooking and canning on the nutritive values of meats have been studied by workers at the Minnesota station who were concerned with thiamine and riboflavin retention in such breakfast favorites as pork link sausage and bacon. The pan-broiled pork sausage retained practically all of the riboflavin originally present in the raw meat, and, on the average, 86 percent of the thiamine. The bacon, similarly, retained all of its riboflavin, but only one-half to two-thirds of its thiamine, depending on whether it was pan-broiled or oven-broiled.

Retention of B-vitamins in home-canned meats

Beef and veal canned in glass and tin at 15 pounds pressure for periods previously found to safely protect against spoilage by *Clostridium botulinum*, were analyzed, as part of a Texas investigation, to see how the processing affected the B-vitamins. The data, compared with those for the raw meat used, showed that riboflavin and niacin were well retained in the canned products, that pantothenic acid retention was about 70 percent, but that retentions of thiamine were 35 percent or less.

The influence of the processing method on retention of B vitamins in home-canned pork was also investigated at the Texas station. In these experiments, paired No. 2 cans of pork were processed at 10 and 15 pounds pressure for the times established as being the lowest for safe processing. Vitamin retention studies, comparing the raw with

the canned meat, showed that more thiamine was retained when the pork was processed in No. 2 cans at 15 pounds for 50 minutes than at 10 pounds for 100 minutes. There were no significant differences in riboflavin, niacin, and panthothenic acid retention in pork processed by these methods.

Effect of processing on nutritive quality of beef protein

Beef from both grass- and grain-fed animals was utilized in experiments by Montana station investigators to determine the effect of canning, roasting, and corning on the nutritive value of the proteins of western beef. Representative raw, cooked, and processed samples of the beef were fed to white rats in experiments to determine the digestibilities and the biological values of the meat protein. The results indicated that the canning process lowered the digestibility slightly but significantly, and apparently caused a slight decrease in biological value of the protein. Roasting and corning did not change either the digestibility or the biological value.

Of particular interest was the fact that beef round from grass-fed and grain-fed animals had similar biological and digestibility values. These findings suggest that western grass-fed beef is nutritionally similar to grain-fed beef. Supplementary studies further showed that the two meats had similar cooking and palatability ratings.

Food preparation

Foods are liked and accepted primarily on the basis of their flavor, texture, and associations in accustomed patterns of eating. Research on food preparation is concerned, therefore, in attaining optimum quality of foods prepared for the table, and at the same time, in retaining the maximum of nutritive values. These objectives are accomplished in experiment station research such as that described below.

Kale, an all-year vegetable

The nutritional values of kale, such as its high content of vitamin A and ascorbic acid and the minerals calcium and iron, were pointed up in [Connecticut] Storrs station studies of locally grown and market-shipped lots of the vegetable. These nutritional virtues, together with the fact that kale is a continuous garden crop, hardy in most parts of the country, have prompted the Storrs station to feature kale as an important vegetable, particularly in areas where winter diets are low in ascorbic acid. For the benefit of the homemaker not especially familiar with kale, ways to use the vegetable have been suggested and recipes have been developed for prepared kale dishes. All this information is conveniently summarized in a folder for popular use, entitled Kale, an All-Year Vegetable.

Mile-high cakes

This title aptly describes the subject of a Colorado station bulletin presenting basic formulas and details of procedure for the baking of cakes at high altitudes. The methods are based on the results of systematic baking trials in a specially controlled high-altitude laboratory established for the study by the Colorado station. The fundamental principles for high-altitude baking were developed in earlier Colorado work on egg white mixtures, mixing methods, yellow sponge cakes, and

balanced formulas, with particular attention to the relation of liquid to other ingredients.

In the new bulletin, referred to above, these technical findings are translated for the housewife into a variety of cake recipes for altitudes of 5,000, 7,000, and 10,000 feet.

Procedure for making quality meringue

"A soft meringue of high quality should be the result if the egg white and sugar are beaten to the proper stage of stiffness and the meringue baked on a warm filling at 425° F. for 4 to 4½ minutes." This assurance is offered by the New York (Cornell) station as a result of experimental work to determine the factors involved in reducing beading, leakage between the meringue and the filling, shrinkage, stickiness upon cutting, and toughness. Experiments, systematically varying the steps in the procedure, served to define the conditions for preparing a quality meringue. The findings indicated that the method must be such as to produce a stable foam, which is then completely coagulated but not overheated.

Food preservation and processing

Research in the field of food preservation and processing has contributed significantly toward extending the marketable life of food products and prolonging their period of use beyond the harvest period. Experiment station researches concerned with these problems have emphasized that the food products must retain the maximum quality and nutritive value compatible with safe processing methods.

Safe methods for canning black-eyed peas at home

Information, such as industry has acquired for the safe processing of commercially canned foods, has been needed to formulate safe processing times for the home canning of foods, particularly the low-acid vegetables. A program of research directed toward accomplishing this need has been under way on a cooperative basis between the Department and several experiment stations. The Texas station in contributing to this program has cooperated in the development of safe processing methods for the home canning of black-eyed peas. This work was undertaken to determine heat treatments that would not result in overcooking and yet would be sufficient to destroy completely the most heat-resistant spoilage organism.

On the basis of this research, the following processing times are recommended: For hot-pack black-eyed peas, 35 minutes for pint glass jars; 40 minutes for quarts; 30 minutes for No. 2 cans; and 35 minutes for No. 2½ or No. 3 cans. Cold packs are not recommended for tin cans but in glass jars may be processed for the same time as hot packs. These recommendations hold for all shelled cowpeas, whether in the immature green, fresh mature, or fresh white mature stage.

Comparative heat-penetration study on jars and cans

The increase in the use of glass jars as containers for commercially canned foods emphasizes the need for comprehensive information on the heating characteristics of foods packed in glass. Experiments, in which the Massachusetts station cooperated, have yielded information

on this problem to help commercial canners prepare safe quality packs of foods.

The time and temperature data obtained in the experiments to determine convection and conduction heating rates in jars and cans were evaluated. The results obtained on 1-percent and 5-percent suspensions of bentonite as the packing medium provided the basis for processing procedures and processing calculations essential in commercial canning operations employing glass jars. Control experiments with inoculated packs of five food products in glass and tin indicated that the findings from the extensive tests on bentonite suspensions were applicable to actual canning operations for foods.

Calcium salts improve texture of frozen berries and asparagus

In tests at the Kentucky station, the addition of calcium chloride or calcium gluconate in varying concentrations to strawberries, raspberries, and asparagus just prior to freezing, resulted in products having firmer tissues and greater drained weights when thawed than products prepared without the calcium treatment. This effect was more pronounced with the gluconate. Treatment with the calcium salts had little or no effect on the ascorbic acid content of the products. These results were obtained with berries and asparagus that had been harvested at the peak of maturity and maintained in prime condition by holding on crushed ice from harvest in the field until preparation for freezing.

Refrigeration improves keeping quality of shelled peanuts

The Georgia station, cooperating with the National Peanut Council and the Refrigeration Research Foundation, carried on exhaustive studies on the keeping qualities of shelled peanuts with and without refrigeration. The research made possible an entirely new formula for controlling temperature, humidity, and ventilation of peanuts in storage. Nuts kept in low-temperature storage were found to have superior flavor and color and were free from insect damage. Activated carbon was found effective in preventing odor absorption and in removing foreign flavor from the nuts.

As the information obtained in these studies get into general use peanuts and peanut products reaching consumers will be of much higher quality than in the past. With better-quality peanuts, growers may expect increasingly larger demands. The annual peanut production in the 12 principal producing States is well over 2 billion pounds. Storage centers in 33 States hold for manufacturers that part of the crop used for candy, roasted peanuts, and other food uses.

Plain aluminum foil a good wrap for frozen meats and poultry

Plain aluminum foil, gage 0.0015, was found in experiments at the Georgia station, to be economical and more efficient in preserving the flavor, aroma, and color, and preventing desiccation of frozen meats and poultry than was cellophane, rubber hydrochloride, polyethylene sheets, parchment, glassine, or various laminated sheets used for wrapping in freezer locker plants. Popular cuts of beef, pork, and chickens were wrapped in aluminum foil by the confectioner's method, overwrapped with lightweight paper, and taped, for 75 cents per 100 pounds. The storage life of meats wrapped thus was about double that of corresponding cuts wrapped in locker paper in the regular manner.

Freeze bacon for future use

Work on the curing of meat at the North Carolina station included studies on bacon cured after storage at 0° F. for various periods. Peroxide values, indicative of rancidity development, were lower for bacon held at 0° for 4 months and stored at room temperature for 3 months than for bacon frozen for shorter periods and held for an over-all period of 7 months. The results suggest that freezing is a good means of holding bacon for future use.

Ultraviolet irradiation of pork frozen for storage

The use of ultraviolet light in meat-aging rooms is a common practice in frozen food locker plants as a means of minimizing microbial growth and the development of off-odors. The effects of this irradiation on the progress of rancidity development in pork, subsequently frozen and stored, has been investigated by the North Carolina station in its meat-curing work and by the New York (Cornell) station. These two studies employed the same type of irradiation but differed somewhat in their approach to the problem. From the results of the North Carolina study it may be concluded that irradiation of pork carcasses for 24- and 48-hour periods cannot be considered to have any deleterious effect, although extremely prolonged aging—up to 8 days—may shorten the storage life. Length of frozen storage period appeared to be a more important factor than irradiation in rancidity development. The findings of the New York (Cornell) study indicate that pork fat if exposed to ultraviolet irradiation, especially for more than 2 days, is more susceptible to rancidity development during subsequent storage than nonirradiated pork fat, particularly at the temperature of 10° F. These findings are in essential agreement with the North Carolina station results. Further work by the New York (Cornell) station indicates that the problem may be minimized by avoiding skinning the carcass or pork cuts prior to chilling or holding and by keeping the time between slaughter and freezing within 48 hours.

The problem of browning in processed foods

The browning reaction, occurring in various processed foods and responsible for a lowering of quality grade, has been the object of research directed at understanding the nature of the reaction and preventing its occurrence. Work to date has shown that the cause and nature of the reaction is not the same in all foods. Trials at the Delaware station showed that the browning of apple slices prior to freezing is caused largely by enzymatic action, which can be inhibited by treatment of the apple slices with an extract of rhubarb. The treatment could be applied to blanched apples or could be used in place of the common blanching process, thereby helping to prevent browning and to preserve the flavor and the soluble substances usually lost in the blanching process. This treatment of apple slices is recommended for the homemaker who has rhubarb available. It is only partially successful, however, in preventing darkening of peach slices.

When overbrowning occurs in the drying of fruit, the quality and price of the product are reduced. It has been of interest to the California station, therefore, to determine the nature of this deterioration. These studies have previously disclosed that, in apricots, furfurals

are formed as intermediate products and are likely to play a part in subsequent darkening. More recent work suggests that amino acids and still another unidentified factor, present in apricot extracts, may be associated with the browning.

Work at the Colorado station has shown that the browning of certain products upon heating is nonenzymatic in nature and is due to intermediate products formed by the interaction of sugars and of amino acids in the food protein. In soybean meal browned by overheating, heat damage to the protein very likely results. This was suggested by experiments in which the isolated soy globulin (a protein fraction) was heated with a glucose solution. Analyses of the darkened heated mixture indicated that large percentages of lysine, arginine, tryptophan, and histidine—amino acids present in the soy globulin—had been destroyed in the heating process.

In the course of the Colorado studies it has also been shown that when sweetened condensed milk is used as directed in certain recipes, significant losses of lysine, arginine, and tryptophan occur. This means that when the sweetened condensed milk is used in recipes involving heat processing, it is probable that a loss in nutritive value will occur because of the nonenzymatic browning reaction.

The nature of the nonenzymatic browning reaction has also been investigated by the Massachusetts station. Results obtained so far indicate that a reaction between sugars and acids in fruit products may contribute to the discoloration in some processed foods. The browning can also be accelerated by the presence of minute amounts of peroxides and minerals in the product.

Red coloring matter in strawberries

Different from any of the above changes is that associated with the loss of red pigment in the darkening of strawberry preserves. Workers at the New York State station have isolated the red pigment in strawberries and have identified it as an anthocyanin. Strawberries contain but little of it, averaging around $^1/_{200}$ ounce in a pound of fruit, but its presence accounts for the bright red color in strawberry preserves and is associated with good flavor and high vitamin C content. In the darkening of these preserves, two types of color changes have been recognized. The most important of these is the loss of the bright red pigment. The other is the development of browning pigments, which occurs gradually in preserves stored below 60° to 65° F. and rapidly at higher storage temperatures. Isolation of the strawberry pigment opens the way for further research on color changes from red to brown in strawberry preserves and other products, and on how to avoid or reduce the rate of loss of the anthocyanin.

Consumption and investment trends in farm family living

Trends in rural family consumption and buying patterns are indicated by studies such as those conducted by the Mississippi and Illinois stations.

Mississippi farm family living

Facts and figures obtained in 1948 concerning the housing facilities, equipment, and furniture of 71 white farm-operator families in Mississippi were compared with similar data obtained on the same families in

1935. The comparison showed greatly improved housing in 1948. It is significant, for example, that in that year 77 percent of the families had electric lights, against 4 percent in 1935; 51 percent had water piped into their homes and 51 percent had mechanical refrigerators, against 6 percent and 3 percent, respectively, in 1935; and 35 percent used gas for heating in 1948, whereas none used it in 1935.

Illinois farm family consumption patterns

Family account books and additional survey material from Illinois rural families gave data for a comparison of the use of income by 185 identical families in 1947 and 1948. The net money receipts of these farm families averaged about the same in these 2 years, only three-fourths of 1 percent more in 1948 than in 1947. Out of the net money receipts for 1948 there were lower savings, higher income tax payments, and a larger expenditure for living than in 1947. When the amount spent for living was adjusted to a constant price level for both years, there was only a 7-percent increase in 1948 over 1947. These families spent less for equipment in 1948 because the majority of their major wants, except for home-freezer lockers, had been satisfied. The amount spent for repairing their houses, including papering, painting, and purchase of new furnishings, increased in 1948.

Among these Illinois families there were 95 that had kept continuous family accounts over many years. Analysis of their household inventories showed that about one-third of the investment was applied to the living area, one-third to the kitchen and laundry, and the remaining one-third to dining and sleeping areas. In addition to indicating consumer trends in buying, this research has been of value to the participating families. It gave them an opportunity to compare their use of income with that of the group average. Thus they could discover their weak and strong points in their management of money.

Home management practices

The farm home, no less than the entire farm, can be made more efficient, and more pleasant to live in when its daily operations are performed on the basis of a carefully thought-out plan of management. Experiment station home economics research includes the goal of helping farm families apply sound management principles to modern homemaking.

Electricity and household work processes

A study of the use of electricity in Oregon rural homes began with a survey of 200 electrified homes in 1945. The survey findings emphasized the need for an electrical plan for farm dwellings that would provide wide latitude in using all parts of the house for a variety of jobs and farm home activities. It became apparent that these should be analyzed with respect to electrical requirements and that the principles of work simplification should be applied to some of the work processes themselves.

Center for hand ironing

Ironing with the use of a corded electric hand iron was studied with the object of devising an ironing center that would reduce the time for the weekly ironing and make the task less tiring. Various specifica-

tions for equipment were formulated on the basis of the ironing practices of a selected group of Oregon homemakers. The sets of equipment were used in a test laboratory, where arrangements were developed to afford economy of space and savings in time and energy.

As a result of the laboratory study, six plans were prepared to serve as patterns for the ironing center. These plans, differing in the equipment used and in the arrangement, are adaptable for use in the various areas of the house where ironing may be done. They provide for adequate space for the worker and suggest that, ideally, the ironing center should include the following: A wide board with parallel edges as well as a narrower board with tapered end, both adjustable for height; an electrical service outlet near the straight end of the board and at least 36 inches above it; an ironing cord long enough to permit reaching all parts of the board, but not so long as to be cumbersome or to muss the clothes while ironing; and, within convenient reach, a container for unironed clothes, a rod or hook for garments on hangers, a table for folded articles, and a rack to air dry articles still damp after ironing. Further, the ironing center should provide storage space for the ironing equipment and should have good light and ventilation.

Provision for this ideal ironing center, simple in detail, requires good management on the part of the homemaker. This should include a house plan provided with, or adaptable for, the required space and the necessary electrical convenience outlets.

Housing

Farm families, like families in towns and cities, do not build more than one or two homes in a lifetime. Many farm homes have been in the family for generations. Therefore, when new homes are planned or when old ones demand repair, it is quite important to farm people that they weigh their expenditures carefully and lay their plan in accordance with the best scientific information available. State experiment stations have found a persistent demand for research that will help rural people get this kind of information. Records show that 46 of the 53 experiment stations are engaged in housing or closely related research; 28 experiment stations are carrying on research that deals with rural housing; and 42 stations are carrying on projects dealing with other farm structures, such as buildings for farm animals and farm products and for the manufacture and processing of farm products. Related studies dealing with essential housing equipment, such as heating, lighting, ventilation, refrigeration, and cooling, are being carried on at 17 stations.

Regional surveys

Research on housing problems is being extensively pursued on a regional cooperative basis in the North Central, Northeastern, Southern, and Western regions. The Department is cooperating in these regional studies. This research is being undertaken with the basic philosophy in mind that housing should provide for families living in homes, not merely for people dwelling in units or developments. The regional studies, although differing in detail, are similar with respect to the long-range plan. This plan provides, first, for a survey to determine what farm families have, need, and want in farm homes; second,

for development in the laboratory of designs, arrangements, and dimensions of facilities in the various working and living areas of the home, in order to meet functional needs, particularly those disclosed in the survey; and finally, for translation of the findings into house plans, as a basis for actual building.

In all four regions, surveys to determine farm family housing needs and preferences have been completed within the year. The population samples for these surveys were chosen by the area-sampling technique to give a picture representative of the region, in each case, rather than the individual States therein. Questionnaires, carefully developed and pretested, were directed by personal interview to a total of 3,918 families in the four regions. The major task of compiling, analyzing, and interpreting the data obtained is well under way. It is the aim of each region to present its housing survey findings in their entirety. This will offer a well-rounded rather than a fragmentary picture of regional housing needs.

Wisconsin pilot study

In conjunction with the North Central regional housing survey, the Wisconsin station conducted a pilot study, in Wisconsin only, to determine the influence of variations in types of farming, income, tenancy, family composition, and area conditions on farmhouse requirements. The survey findings indicate that farmhouses are not generally designed to accommodate farm families as they exist; that building for the "average size" farm family gives a house that is too small for nearly 10 years of the average farm family's lifetime. The Wisconsin farm families studied average 3.58 persons, but began with 2 or 3 persons, built up to a maximum average household of nearly 7, and maintained that level for several years. The household then decreased gradually to almost its beginning size. In addition to the natural family, nearly every farm had relatives or "outsiders" living in its home for at least part of 2 years out of 5, suggesting the need for planning farm homes for privacy and other accommodations. In addition, most of the farm families had lived in several houses during their family lifetime, indicating that most farmhouses should be designed for families larger than the first one to occupy the house.

A limited survey of Wisconsin postwar farmhouses showed that they were generally rather small, particularly those built for tenants. Owner houses generally had more conveniences than tenant houses, and the postwar owner houses were larger than postwar tenant houses, both on an actual size and on room-per-occupant bases.

RURAL SOCIOLOGY

Rural sociology and cultural anthropology are entering increasingly into the research carried on at experiment stations. Group behavior, and the way the individual lives of persons in the community are affected by activities in the community, are of increasing concern to those who want to insure a lasting democratic way of life. Our democratic institutions are founded on traditions and ways of life that have come down to the present generation through qualities of independence, self-reliance, self-discipline, and sacrifice established by generations that have gone before. Much of this cultural inheritance still prevails

in rural areas. Gathering sound and factual information whereby these characteristics of American democracy can be perpetuated and fitted into life under rapid technological changes is the field of research in which the rural sociologist is engaged. Examples of such research reported in the past year follow.

Rural Negro families in Maryland

The economic and social status of rural Negro families in the State was investigated by the Maryland station. A desirable pattern for getting facts on how large segments of rural people live was established and a priority of problems to solve formulated in order to reach underprivileged rural groups effectively with extension and similar educational programs. The facts obtained in the study will be used by the Extension Service in planning and developing a better extension program to meet the needs of most of Maryland's 120,000 rural Negro citizens.

Personality adjustments in youth

A health and human development survey, conducted in the Miami Valley by the Ohio Experiment Station in cooperation with the Division of Mental Hygiene of the State Department of Public Welfare, indicated that youths in the area coming from rural homes had, in general, more mental health assets and fewer liabilities than those from urban homes. The study, which has been under way in the Miami Valley for several years, was concentrated in Butler County during the past year. More than 800 rural and urban students in the tenth grade were given a standardized test of mental health assets and liabilities. Previous studies of a similar nature in Miami County brought similar results. Establishment of a guidance center after the first year's work resulted in raising the mental health level of children in that county. Research like this, carried on by qualified agencies, points the way by which communities may take action that will aid individuals, especially youth, in adjusting themselves favorably to their environment.

Population changes in Kentucky mountains

After making a study of rural population changes in five mountain districts, the Kentucky station found that early in the war, in 1942 and 1943, people left in great numbers, but by the summer of 1946 the stream of out-migration had dwindled until more were returning than leaving. During the first part of the war more men than women left, but from 1943 to 1946 many more women than men left the rural districts. Most out-of-State migrants went to southern Ohio. Since the war, people, mostly natives, have been returning to their former Kentucky homes.

In-and-out migration and births and deaths have combined to bring significant population changes in the districts studied. The 1946 population, of these predominantly rural farm districts, was between 20 percent and 30 percent less than in 1940. By the summer of 1946 the population was beginning to increase again. During these changes in population the educational level of the districts changed very little.

Farm population trends in Washington

The Washington station reports that because of the marked decline of immigration from abroad the proportion of foreign born in the

population in Washington has been decreasing. The ratio of the foreign born of Finnish, Italian, Norwegian, and Russian origin, however, was found to have been on the increase since 1910. Farmers and farm managers were found to be the least migratory of all occupational groups. The evidence supported the common observation that farm laborers are very migratory. However, professional people were found to be even more migratory than farm laborers. Nearly a third of the employed heads of the rural farm households were engaged in occupations other than farming.

Washington, along with Massachusetts, had the highest proportion of part-time farmers of any of the States in the nation in 1944. The sex ratio among unmarried farm adults aged 20 to 29 was found to be excessively high. Washington is in a favorable position with respect to the education of its children, since it has a low ratio of children of school age. The data show that farms in Washington are becoming fewer and, on an average, larger. However, suburbanization has also been going on, with thousands of people filing out of the cities into the countryside and living on small plots classified by the census as farms.

Michigan public school enrollment

According to the Michigan station the enrollment in the public schools of Michigan can be expected to rise annually and by substantial additions for another 8 years. An enrollment of 1,210,000 can be expected in 1955-56. The rising tide of school enrollments is creating needs for additional school buildings, school equipment, and teachers. These increased enrollments also point to the desirability of studying the 100-year-old school-district organizational set-up with a view to reducing educational inequalities.

Family-type sugarcane farming

Records were collected by the Louisiana station from 503 family-type sugarcane farms in 1946 and 500 in 1947. The sample studied represented between 5 and 10 percent of all family-type sugarcane farms in Louisiana in the 1946-47 period and is similar in size and composition to the sample of farms surveyed in the 1938-45 period. The average size of the family-type sugarcane farms studied for the 1946-47 period was about 75 acres, including 54 acres in cropland of which 26 acres were planted to sugarcane. About 37 percent of these farms were operated by producers who owned their farms, 19 percent were operated by growers who owned part of their land and rented part, 18 percent were operated by cash renters, and 26 percent by share renters. The most significant changes in the organization of family-type sugarcane farms in Louisiana in recent years have been the shift toward smaller operating units maintained primarily with family labor and the change from mule to tractor farming.

Mechanized v. nonmechanized methods

An analysis of the production requirements under mechanized and nonmechanized methods of farming made by the Louisiana station indicates that the substitution of tractors for mules usually resulted in a reduction in the cost of power, a reduction in the amount and consequently the cost of labor, an increase in output per worker, an increase in capital requirements, and greater opportunities for develop-

ing productive livestock enterprises. This change to mechanized methods also encourages diversification of cropping systems and increases managerial responsibility. The cost of power for producing crops in 1944 on a 230-acre mechanized-diversified farm was $1,422. On a mechanized-specialized 230-acre cotton farm the cost of power was $1,396. On a specialized 230-acre cotton farm operated entirely with mules the cost of power was $3,153. The margin in favor of mechanical power is over $1,700 on a farm of this size, not to mention other economies afforded through efficient utilization of other resources.

Two-thirds of workers may be displaced

The Mississippi station concluded that when mechanization is completed perhaps two-thirds of those in present plantation areas will be displaced by full mechanization. Those remaining on mechanized farms will have more money to pay for goods and services than ever before. Industrialization will be needed to provide employment for those displaced by mechanization. Farmers with ability in dairying, livestock, and poultry will find opportunities to remain on the farms, and the displaced persons and families will need to be helped in locating industrial jobs within or out of the State. They will also need vocational training leading to urban employment. The shift from older methods of cotton production to mechanization is occurring rather painlessly because of good economic conditions and also because mechanization has been slowed as a result of difficulties in developing effective methods of weed control that will eliminate hand operations.

Social effects of mechanization

Some of the social effects of mechanization on American agriculture have been pointed out by the Oklahoma station. Tractors were first manufactured in 1903. By 1910 they numbered about 1,000; by 1920, 246,000; and in 1948 an estimated 3.2 million. Mechanization is now spreading through the South causing many farm laborers to seek work in other occupations. Mechanization affects the age composition of the farm population by reducing the number of children and youths of working age and, consequently, increasing the proportion of the total population in the older age groups. It is also associated with an increase in the number of part-time or subsistence farms and of large farms. Changes in ownership and tenancy are retarded by mechanization. Of all United States farms, 68 percent were owner-operated in 1945 compared with 61 percent in 1920. In contrast, in 67 Oklahoma counties, increases in proportions of farms owner-operated were much smaller in highly mechanized farming communities than elsewhere during the period studied.

Farm laborers are affected more than any other class by mechanization. Increases in total acreage and some decreases in cropland acreage accompany mechanization. Cultivated land has been shifted to crops better adapted to mechanization. In Oklahoma the cotton and wheat acreages have declined where the least mechanization is practiced and have risen sharply in areas where powered machinery is used extensively. Commercialization also accompanies mechanization. In 1944, 90 percent of the Nation's farm products were sold, the remainder being used on farms. The trend toward sale of larger proportions of total products raised is accentuated by farm mechanization. While

the commercialization of agriculture is not considered undesirable from the social viewpoint, according to the Oklahoma station it does tend to expose the farmer's welfare to the fluctuations of the business cycle and tends to make him increasingly dependent upon Government for security with subsequent loss of traditional self-sufficiency and autonomy.

Farm mechanization correlates fairly well with distribution of farm wealth and income. Stated another way, adequate capital resources are a prerequisite to mechanization. The level of living of farm operator's families correlates rather closely with the amount of farm mechanization. However, the relative increase in proportions of farms with telephones, electricity, running water, and automobiles between 1920 and 1940 was less in the 24 States with highest mechanization indexes than in the other States. The gains in incomes of mechanized farms were absorbed by large capital outlays for mechanization. The cash costs of mechanized farms may be so high as to reduce the proportion of total farm income available for family living. On the other hand, farm families probably enjoy more leisure and religious and other social activities as a result of mechanization.

Other effects of mechanization in Oklahoma are the consolidation of small schools with village and city systems and the townward movement of rural churches and recreational facilities. Farm people through these increasing contacts with village and city people are becoming more urbanized in attitudes and behavior. Mechanization will be retarded in many areas because farms are small, there is a lack of working capital, there is a density of farm populations, lands are hilly, and types of diversified farming not yet adapted to the use of tractors are practiced. An adverse feature of mechanization is its tendency to step up the production of food and fibers beyond effective peacetime demand.

Part-time farming in Tennessee

From a part-time farming survey in the Knoxville farm-industrial area of the State, the Tennessee station found that a rapid population growth in areas bordering city and country, taking place throughout the Nation, reflects an adjustment to changing economic conditions both urban and rural. Farms with between 2 and 16 acres in crops appeared to be more profitable than those either smaller or larger. The rate of returns showed greatest increase when both cow and hog numbers increased. High production rates were important to the success of part-time farms, but apparently not as important as a good choice of crops and livestock designed to produce as much of the family's food as possible with low inputs of labor and capital. The number of years that a family farmed part-time had some bearing on the size of operations. Acreage in crops and pasture doubled after about 3 years, and then declined for those who had farmed over 15 years.

Crop yields were higher, farm operations were more extensive, and incomes were greater for the farms on better-than-average soils. Heavy concentrations of part-time farming in a community may pose certain problems. Allegiances may be divided between the local community and the larger trade area where work is obtained. Interests are split between agriculture and industry, with industrial interests fanning out

in many directions. This raises a challenge in community organization, for unless appeals reach all interests, response becomes poor.

Keeping the farm in the family

After studying the problem of transferring the family farm from one generation to the next with a maximum of economy and social gain, the Missouri station reported that transmitting the farm from father to a single heir is desirable from the standpoint of maintaining a farming unit of adequate size. This makes it necessary to satisfy the claims of other heirs without requiring a subdivision of the farm, and, if possible, without loading down the operating heir with an impracticable burden of debt. A more practicable method of passing the farm on to a succeeding operator is suggested. It would make him liable for the rent value of the property plus an additional sum which, within a reasonable period of years, would amortize the capital value of the property. Such a procedure would introduce inheritance of rent income rather than capital value of an heir's share in the estate.

Families on small farms still need many things

From a study of size and economic class, the Oklahoma station reached the following conclusions: A relatively few large farms, approximately 7 or 8 precent of the total, include from 30 to 40 percent of the total farm resources and account for more than one-third of the total farm production of the State. About 44 percent of the farms in Oklahoma, with 10 to 16 percent of the total farm resources, produce one-tenth of the total gross farm income. Despite broad gains made in the level of living during World War II, 83 percent of the farm families are without running water in the home, 75 percent have no telephones, 71 percent lack electricity, 39 percent do not have automobiles, and 26 percent possess no radios. Most families without these items live on small farms. From the data available it is apparent that the type and organization, and consequently the problems, of small farms differ greatly from the corresponding characteristics of middle-sized and large farms.

EXAMPLES OF FUNDAMENTAL RESEARCH

Research carried on by the State agricultural experiment stations carries with it a considerable amount of basic and fundamental study. The discovery of new scientific knowledge may be a major objective in a research project and the acquiring of new knowledge may be an incidental byproduct of studies seeking practical application of previously established principles. The following are several outstanding examples of fundamental research reported by State experiment stations during the past year.

Ultrasonic waves bring nuclear changes

The Connecticut station at New Haven has shown that ultrasonic vibrations produce chromatid and chromosome breaks and other nuclear aberrations. In many respects the immediate effect of these on plant cells is similar to the primary and secondary effects created by electro-magnetic waves or by mustard gas. The technique developed by the Connecticut station shows great promise in the

progress of fundamental science dealing with chromosome structure and cellular mechanics of plant cells. Such changes as took place in the cells appeared primarily to be caused by mechanical vibrations.

Metabolism of plants and animals

The advent of atomic science, with its practical use of radioactive charged isotopes in agricultural research, has greatly speeded soil and fertilizer and similar research in the practical and applied field. It has also resulted, in research dealing with the metabolism of plants and animals, in several discoveries of far-reaching effect.

Simple sugars produced with radioactive carbon

In studies dealing with the metabolism of plants and animals, California station workers have, for the first time, succeeded in producing in the plant simple sugars containing radioactive carbon. The California studies have brought scientific research a step closer to discovery of the life processes involved in photosynthesis. All life on the planet depends on this process whereby energy from the sunlight reduces carbon from carbon dioxide in the atmosphere into simple sugars and other carbohydrates. The California results were obtained by exposing plants in sunlight to an atmosphere containing carbon dioxide in which the carbon atoms were radioactive.

Several years ago the same laboratory discovered a method whereby crystalline sugar can be synthesized by the use of enzymes similar to those occurring in nature. Until now, however, the behavior of simple sugars like glucose and fructose, during the course of metabolism, could not be observed, since it was impossible to distinguish one sugar fragment from another. Use of the tracer technique, whereby radioactive carbon isotopes are incorporated in the sugar molecules, permits direct observation of the course of changes taking place in individual compounds. From the standpoint of immediate application, the California laboratory is also turning over to the Medical School of the University of California radioactive glucose for research aimed at finding a solution of the process by which diabetic animals break down sugar.

Carbon dioxide used by nonphotosynthetic bacteria

Until very recently it had generally been believed that only green plants and certain pigmented algae and bacteria could make use of carbon dioxide in carrying out life processes. As early as 1935 some scientists claimed that carbon dioxide could also be used by nonphotosynthetic bacteria. Their theory was not accepted until last year when the Iowa station, through the use of an isotope of carbon (C_{14}) confirmed the 1935 theory. The research has, therefore, opened up an entirely new avenue of approach to study photosynthesis. If the role that carbon dioxide plays in carbohydrate-and-amino-acid synthesis can be determined in bacteria, its function in the plant might be more readily understood.

The Wisconsin station, in a U. S. Public Health Service supported project, showed that, along with other functions, the vitamin biotin is apparently important in permitting both bacteria and animals to use carbon dioxide. The Wisconsin research was also conducted with the use of radioactive carbon.

Neomycin isolated from soil

The New Jersey station has announced isolation from soil samples of an organism producing neomycin, an antibiotic which, after methods have been found to produce it in crystalline form, will be highly valuable in medical practice. This recent addition to the growing list of antibiotics is relatively heat stable, is active against numerous bacteria that cause serious diseases such as tuberculosis, and has only slight toxic effect on animals. Neomycin is similar in its antimicrobial properties to streptomycin, except for the added advantage that it is particularly active against those bacteria which have become resistant to streptomycin.

STATISTICS—PERSONNEL, PUBLICATIONS, INCOME, AND EXPENDITURES

Personnel and publications

The research personnel of the experiment stations in 1949 included 2,836 staff members devoting full time to station research and 3,009 who divided time between research and teaching or extension work. The total in both categories, 5,845, represented an increase of 452 over the total of 1948 and there were 190 more full-time workers in 1949.

Publications of the experiment stations in 1949 included 768 bulletins, circulars, and reports; 3,129 articles in scientific journals; and 769 miscellaneous publications. By comparison with 1948, the stations published 86 fewer bulletins, circulars, and reports, 439 more articles in scientific journals, and 160 fewer miscellaneous publications.

Data by individual States relating to personnel and publications are shown in table 1.

Income and expenditures

Appropriations under the authorizations of the Hatch, Adams, and Purnell Acts for use by the experiment stations in 1949 totaled $4,500,000, each State, Hawaii, and Puerto Rico receiving $90,000. A total of $2,861,080.14 was appropriated under the Bankhead-Jones Act of June 29, 1935, with allotments to the individual States, Hawaii, and Puerto Rico as shown in table 2. These allotments are made primarily on the basis of rural population adjusted in accordance with the provisions of the Department of Agriculture Organic Act of 1944.

The total amount of Federal-grant funds appropriated to this Office under the Hatch, Adams, and Purnell Acts, and title I of the Bankhead-Jones Act, was $7,361,268. Of this total $187.86 which would have been available to the Alaska station was transferred to the departmental appropriation "Research on Agricultural Problems of Alaska," as required by law.

Under title I, section 9, of the Research and Marketing Act of 1946, $3,250,000 was appropriated. Of this total $97,500, authorized by section 9 (c) of the act was available to the Office of Experiment Stations for administration. Of the remainder $2,326,401.57 was allotted to the States, Hawaii, and Puerto Rico, under the formulas described in sections 9 (b) (1) and (2); $808,150 was available for allotment, of which all but $300 was allotted, to the States for cooperative regional re-

search projects authorized by section 9 (b) (3); $4,350 was available for travel by the Committee of Nine established in accordance with section 9 (b) (3), and $13,598.02, which would have been paid to Alaska in accordance with sections 9 (b) (1) and (2), was transferred to the departmental appropriation "Research on Agricultural Problems of Alaska" as required by the Department of Agriculture Appropriation Act for fiscal year 1949. The amounts allotted under sections 9 (b) (1), (2), and (3) are shown in table 2. Also shown are the unexpended balances of allotments for fiscal year 1948, which were available for expenditure during fiscal year 1949.

In addition to the Federal-grant funds enumerated above, the Office for the first time received funds from title II of the Research and Marketing Act for allotment to the State agricultural experiment stations for marketing research. Allotments totaling $60,500 were made to the stations during the fiscal year 1949.

Non-Federal income of the stations appears in table 3.

Expenditures of Federal-grant funds are shown under object classes by individual experiment stations in tables 4, 5, 6, 7, 8, and 9, expenditures of non-Federal funds in table 10. The 1949 expenditures of non-Federal funds which include State appropriations, research grants, and income from other sources totaled $40,304,508.38, as compared with $35,350,485.98 in 1948. The 1949 non-Federal fund expenditures by all of the stations approximated $3.84 for each $1 of Federal grants. A summary of expenditures appears in table 11.

Expenditures and allotments of funds from title II of the Research and Marketing Act are shown in table 12.

TABLE 1.—*Organization, personnel, and publications of the experiment stations for the year ended June 30, 1949*

Station	Date of legislative assent to Hatch Act	Date of organization under Hatch Act	Personnel					Publications					
			Full-time research	Research and teaching	Research and extension	Research, teaching, and extension	Total research workers	Station publications		Articles in scientific journals		Miscellaneous publications	
			Number	*Number*	*Number*	*Number*	*Number*	*Number*	*Pages*	*Number*	*Pages*	*Number*	*Pages*
Alabama	Feb. 27, 1889	Apr. 1, 1888	59	37		1	97	8	236	29	155	37	398
Arizona	Mar. 19, 1889	July 1, 1889	26	37	1		64	21	507	16	72	12	42
Arkansas	Mar. 7, 1889	Apr. 2, 1888	24	42		1	67	11	359	7	43		
California	Mar. 12, 1889	Mar. 13, 1888	114	249			363	28	1,041	605	5,644	33	652
Colorado	Mar. 25, 1889	Feb. 20, 1888	36	79	1		116	4	194	30	(1)	28	(1)
Connecticut:													
State	May 18, 1887	May 18, 1887	61				61	21	838	33	196	8	19
Storrs	do	Apr. 1, 1888	30	15	5	3	53			27	166	8	79
Delaware	Apr. 14, 1887	Feb. 21, 1888	14	13	3	4	34	9	143	21	89	5	5
Florida	June 7, 1887	Mar. 16, 1888	127	18	5	5	155	26	1,079	142	462	74	98
Georgia	Dec. 24, 1888	Feb. 18, 1888	94				94	27	273	15	(1)		
Hawaii	Mar. 31, 1911	July 1, 1929	33	13	1	1	48	6	325	15	112		
Idaho	Jan. 23, 1891	Feb. 26, 1892	16	35		3	54	11	283	13	58	1	8
Illinois	May 11, 1887	Mar. 21, 1888	68	112	8	5	193	23	862	120	777	25	188
Indiana	Jan. 19, 1889	July 1, 1887	86	62	6	12	166	29	747	53	212	48	100
Iowa	Mar. 1, 1888	Feb. 17, 1888	89	142	20	6	257	26	1,274	83	770	3	160
Kansas	Mar. 3, 1887	Feb. 8, 1888	42	36			78	14	694	124	992	79	474
Kentucky	Feb. 20, 1888	Apr. 29, 1888	89	20	4	12	125	19	934	45	172		
Louisiana	July 12, 1888	Apr. 5, 1887	79	47	1		127	13	448	48	243	29	127
Maine	Mar. 16, 1887	Feb. 16, 1888	35	19	1	2	57	21	823	10	44	6	30
Maryland	Mar. 6, 1888	Mar. 9, 1888	29	25	7	19	80	4	129	27	140	15	156
Massachusetts	Apr. 20, 1887	Mar. 2, 1888	78	18			96	23	469	47	289		
Michigan	Apr. 12, 1889	Feb. 26, 1888	89	95	16	9	209	15	919	55	371		
Minnesota	Feb. 4, 1889	Jan. 26, 1888	45	129	3	4	181	13	430	75	825	37	168
Mississippi	Jan. 31, 1888	Spring, 1888	58	19		8	85	20	449	30	189	42	146
Missouri	June 11, 1889	Jan. 31, 1888	15	97		4	116	17	334	39	(1)	1	(1)
Montana	Feb. 16, 1893	July 1, 1893	28	37	1	10	76	13	344	8	74	3	104
Nebraska	Mar. 31, 1887	June 14, 1887	43	58			101	14	647	22	(1)		
Nevada	Feb. 8, 1889	Dec. 1887	15			1	16	3	65				
New Hampshire	Aug. 4, 1887	Feb. 22, 1888	12	40	1	6	59	8	169	9	45		

New Jersey	Mar. 16, 1887	Mar. 5, 1888	49	66	2	2	119	27	475	91	528	70	586
New Mexico	Feb. 28, 1889	Nov. 14, 1889	21	24	1	2	48	7	219	7	20	8	70
New York:													
Cornell	Mar. 30, 1887	Apr. 30, 1888	30	145	8	25	208	13	830	534	2,592	----	----
State	(2)	----	64	----	----	----	64	14	373	34	(1)	----	----
North Carolina	Mar. 7, 1887	Dec. 5, 1889	98	60	1	4	163	9	324	35	(1)	----	----
North Dakota	Mar. 8, 1890	Oct. 15, 1890	36	27	----	----	63	11	477	41	87	----	----
Ohio	Mar. 16, 1887	Apr. 2, 1888	128	45	----	----	173	17	645	101	(1)	9	(1)
Oklahoma	Oct. 27, 1890	Aug. 14, 1891	42	75	1	----	118	24	572	100	354	2	204
Oregon	Feb. 25, 1889	July 2, 1888	80	69	----	3	152	34	823	50	(1)	----	----
Pennsylvania	June 3, 1887	June 30, 1887	----	183	----	----	183	16	397	59	428	21	330
Puerto Rico	Aug. 16, 1933	Nov. 14, 1935	79	----	----	----	79	10	867	9	(1)	15	(1)
Rhode Island	Mar. 31, 1887	Nov. 3, 1888	22	16	1	5	44	8	232	19	67	5	42
South Carolina	Dec. 22, 1887	Jan. 1888	65	22	3	1	91	6	346	4	12	----	----
South Dakota	Mar. 11, 1887	Nov. 17, 1887	27	31	2	1	61	11	250	13	(1)	----	----
Tennessee	Mar. 29, 1887	July 24, 1887	53	29	1	7	90	11	467	17	161	8	320
Texas	Apr. 2, 1887	Jan. 25, 1888	190	47	----	10	247	16	729	80	365	99	425
Utah	Mar. 8, 1888	Nov. 6, 1889	35	47	----	5	87	15	502	12	69	1	12
Vermont	Nov. 1888	Feb. 28, 1888	6	17	4	9	36	8	216	9	80	----	----
Virginia	Feb. 29, 1888	June 13, 1888	91	15	1	6	113	7	121	45	218	5	9
Washington	Mar. 9, 1891	May 1, 1891	92	76	----	----	168	27	594	89	467	21	136
West Virginia	Feb. 22, 1889	June 11, 1888	16	51	1	3	71	10	237	16	110	----	----
Wisconsin	(3)	July 1, 1887	55	106	4	19	184	11	444	----	----	----	----
Wyoming	Jan. 10, 1891	Mar. 27, 1891	23	31	----	1	55	9	326	16	115	11	50
Total	----	----	2,836	2,676	114	219	5,845	768	25,481	3,129	17,813	769	5,138

(1) Total pages unknown.
(2) First made eligible to receive part of the State allotment of Federal funds by legislative act approved May 12, 1894.
(3) Session of 1887.

TABLE 2.—*Federal funds available to the experiment stations for the year ended June 30, 1949*

Station	Federal-grant funds[1]							Contractual Federal funds, Research and Marketing, Title II, 1949 Appropriation	Total Federal funds available
	Hatch, Adams, and Purnell[2]	Bankhead-Jones	Research and Marketing, Title I				Total		
			Sections 9 (b) 1 and 9 (b) 2		Section 9 (b) 3				
			Carry-over from 1948	1949 Appropriation	Carry-over from 1948	1949 Appropriation			
Alabama	$90,000	$96,152.81	$5,342.71	$76,919.41	$1,656.90	$13,200.00	$283,271.83	$7,700	$290,971.83
Arizona	90,000	15,499.36	4,182.71	20,468.52	1,701.91	9,450.00	141,302.50		141,302.50
Arkansas	90,000	74,312.76	14,264.11	64,190.55	18.50	15,700.00	258,485.92		258,485.92
California	90,000	95,542.61	21,918.15	59,421.35	726.49	45,000.00	312,608.60	900	313,508.60
Colorado	90,000	26,055.98	7,673.98	27,132.69	7,532.90	24,575.00	182,970.55		182,970.55
Connecticut:									
State	45,000	13,129.28	6,528.65	11,729.49			76,387.42		76,387.42
Storrs	45,000	13,129.28	5,080.38	11,729.50	49.93	6,100.00	81,089.09		81,089.09
Delaware	90,000	6,054.94	8,816.57	15,795.94	2,000.00	1,000.00	123,667.45		123,667.45
Florida	90,000	40,579.22	13,394.75	33,115.05	2,207.00	6,900.00	186,196.02		186,196.02
Georgia	90,000	101,476.80	2,766.06	78,620.93	5,504.54	14,800.00	293,168.33	5,000	298,168.33
Hawaii	90,000	10,269.39	10,032.61	18,492.76			128,794.76		128,794.76
Idaho	90,000	16,589.81	4,727.50	23,143.22		16,500.00	150,960.53		150,960.53
Illinois	90,000	100,946.87	35,791.74	68,817.22	9,237.76	26,050.00	330,843.59		330,843.59
Indiana	90,000	73,383.88	21,616.31	56,619.36	7,654.37	22,000.00	271,273.92		271,273.92
Iowa	90,000	74,752.37	7,766.20	58,426.74	23,741.86	54,350.00	309,037.17	3,700	312,737.17
Kansas	90,000	57,178.54	2,975.13	43,955.41	1,853.26	7,850.00	203,812.34		203,812.34
Kentucky	90,000	95,122.25	19,134.89	75,013.23	1,815.46	6,900.00	287,985.83		287,985.83
Louisiana	90,000	65,919.96	22,112.89	55,365.98	6,271.33	11,500.00	251,170.16		251,170.16
Maine	90,000	24,124.05		24,686.34		15,670.00	154,480.39	4,000	158,480.39
Maryland	90,000	35,303.01	5,435.96	29,936.10	1,220.44	10,885.00	172,780.51		172,780.51
Massachusetts	90,000	21,787.39		23,238.20	900.00	11,600.00	147,525.59		147,525.59
Michigan	90,000	85,827.73	14,410.17	61,823.19	7,422.40	15,000.00	274,483.49	9,500	283,983.49
Minnesota	90,000	66,813.91	32,157.01	57,250.18	9,774.33	19,700.00	275,695.43		275,695.43
Mississippi	90,000	84,569.98	12,563.17	75,266.54	3,570.57	32,300.00	298,270.26	7,300	305,570.26
Missouri	90,000	89,383.63	15,439.59	68,925.51	8,256.97	13,734.80	285,740.50		285,740.50
Montana	90,000	17,871.46	2,842.37	22,433.69	1,428.01	6,800.00	141,375.53		141,375.53
Nebraska	90,000	44,233.72	6,258.09	37,532.97	120.24	9,765.20	187,910.22		187,910.22
Nevada	90,000	3,190.40		14,130.07		2,100.00	109,420.47		109,420.47
New Hampshire	90,000	9,925.30	7,887.06	17,616.28	4.93	4,200.00	129,633.57		129,633.57

New Jersey	90,000	36,470.37		27,558.70	12,501.46	14,950.00	181,480.53	1,500	182,980.53
New Mexico	90,000	16,935.36	12,157.70	22,602.56	4,985.74	10,550.00	157,231.36		157,231.36
New York:									
Cornell	81,000	99,202.17	14,705.12	58,904.77	3,622.44	57,560.00	314,994.50	3,000	317,994.50
State	9,000	11,022.46	3,105.03	6,544.97			29,672.46	6,500	36,172.46
North Carolina	90,000	123,766.51	15,989.82	94,261.74	7,849.06	29,300.00	361,167.13		361,167.13
North Dakota	90,000	28,147.42	1,613.30	28,806.94	2,123.88	1,800.00	152,491.54		152,491.54
Ohio	90,000	109,337.26	37,110.38	74,715.21	966.95	9,650.00	321,779.80		321,779.80
Oklahoma	90,000	78,367.16	5,033.77	58,455.46	2,854.92	8,500.00	243,211.31		243,211.31
Oregon	90,000	26,588.72	8,187.04	27,655.63	15,365.89	27,700.00	195,497.28	6,000	201,497.28
Pennsylvania	90,000	157,876.48	9,860.84	84,736.61	2,097.08	15,235.00	359,806.01		359,806.01
Puerto Rico	90,000	62,082.14	15,074.14	59,984.43		3,500.00	230,640.71		230,640.71
Rhode Island	90,000	2,857.19	3,656.12	14,067.99	470.49	12,485.00	123,536.79		123,536.79
South Carolina	90,000	69,224.19	5,234.74	57,756.29	2,713.55	21,200.00	246,128.77		246,128.77
South Dakota	90,000	27,733.01	5,412.09	27,896.54	2,145.00	10,200.00	163,386.64		163,386.64
Tennessee	90,000	89,992.09	8,317.33	73,852.04	885.56	12,100.00	275,147.02		275,147.02
Texas	90,000	173,212.81	28,353.84	120,598.71	18,113.74	40,200.00	470,479.10	4,400	474,879.10
Utah	90,000	12,170.15	867.84	19,050.92	2,523.91	29,545.00	154,157.82		154,157.82
Vermont	90,000	12,078.01	4,489.47	18,973.89	3.03	2,850.00	128,394.40		128,394.40
Virginia	90,000	82,941.86	1,875.90	63,920.34		11,320.00	250,058.10		250,058.10
Washington	90,000	38,797.09	8,864.13	33,513.03	6,156.50	24,600.00	201,930.75		201,930.75
West Virginia	90,000	65,169.05	20,453.58	46,587.31	2,175.29	9,425.00	233,810.23		233,810.23
Wisconsin	90,000	70,152.59	8,961.21	57,216.01	3,720.07	23,050.00	253,099.88	1,000	254,099.88
Wyoming	90,000	7,829.36	10,412.55	16,945.06	2,849.74	8,500.00	136,536.71		136,536.71
Total	4,500,000	2,861,080.14	540,854.70	2,326,401.57	198,794.40	807,850.00	11,234,980.81	60,500	11,295,480.81

[1] Includes unexpended balances from the previous year as follows:
Hatch — Connecticut State, $12.16; Connecticut Storrs, $148.87; Maryland, $0.30; New York Cornell, $13.01.
Adams — Arkansas, $102.70; Delaware, $982.99; Hawaii, $1,590.24; New York Cornell, $64.41; New York State, $81.90; Ohio, $0.50.
Purnell — Arkansas, $658.04; Connecticut State, $163.17; Connecticut Storrs, $204.75; New York Cornell, $522.42; New York State, $38.37; Ohio, $0.32; Texas, $0.05.
Bankhead-Jones — Arkansas $1,040.43; Connecticut State, $47.23; Connecticut Storrs, $286.56; Maryland, $2.84; New York Cornell, $0.89; Pennsylvania, $0.01; Texas, $0.34; Virginia, $8.04.

[2] Hatch, $15,000 for each State, Hawaii, and Puerto Rico. Adams, $15,000 for each State, Hawaii, and Puerto Rico. Purnell, $60,000 for each State, Hawaii, and Puerto Rico.

NOTE:—Federal-grant funds formerly paid to the Alaska Agricultural Experiment Station of the University of Alaska were transferred to and made a part of the appropriation "Research on Agricultural Problems of Alaska." This appropriation was administered by the Agricultural Research Administration of the Department of Agriculture.

TABLE 3.—*Non-Federal funds available to the experiment stations for the year ended June 30, 1949*

Station	State appropriations	Special endowments, industrial fellowships, etc.	Fees	Sales	Miscellaneous	Balance from previous year	Total
Alabama	$ 414,150.00	$101,522.69		$370,754.67	$6,949.50	$310,773.61	$1,204,150.47
Arizona	298,396.19	9,008.21		36,521.84			343,926.24
Arkansas	305,100.00	11,791.27		136,328.88		40,877.91	494,098.06
California	3,402,743.46	158,651.52		200,252.15		225,644.34	3,987,291.47
Colorado	205,810.41	97,991.50		87,390.10	4,571.50	90,969.56	486,733.07
Connecticut:							
State	322,096.29	17,079.69					339,175.98
Storrs	279,756.65	31,400.16					311,156.81
Delaware	51,591.40			91,456.09	10,410.32	30,968.27	184,426.08
Florida	1,723,205.00	26,412.95		162,433.35	271,827.09	374,527.54	2,558,405.93
Georgia	137,550.00	28,807.53	$4,782.92	64,580.29	55,360.00	68,111.26	359,192.00
Hawaii	395,665.66	6,237.17		56,501.12	1,735.46	5,180.96	465,320.37
Idaho	176,497.13	36,996.83		79,570.43		52,083.49	345,147.88
Illinois	1,187,082.99	159,769.22		299,935.83			1,646,788.04
Indiana	683,777.69	147,645.98	191,500.00	487,703.89	10,029.02	549,073.87	2,069,730.45
Iowa	761,576.03			454,729.70		221,504.44	1,437,810.17
Kansas	221,653.01			166,632.00	67,093.27	152,571.30	607,949.58
Kentucky	230,434.42		198,250.29	56,000.00			484,684.71
Louisiana	951,628.47	75,211.76					1,026,840.23
Maine	189,040.24			67,809.73	9,550.42	37,022.99	303,423.38
Maryland	216,311.35	13,336.50		67,168.00		92,800.60	389,616.45
Massachusetts	354,312.67	20,545.35				28,730.97	403,588.99
Michigan	742,677.83			44,588.87		9,157.76	796,424.46
Minnesota	1,066,422.43	102,293.06	9,900.95	246,429.51			1,425,045.95
Mississippi	785,681.48	34,661.39		393,379.53	44,940.74	102,768.45	1,361,431.59
Missouri	176,800.00	35,071.03	141,147.13	107,129.67		242,090.14	702,237.97
Montana	271,268.88	7,690.76		352,232.92	553.84	218,620.71	850,367.11
Nebraska	354,461.75			302,353.56			656,815.31
Nevada	24,321.11			38,141.23		4,106.10	66,568.44
New Hampshire	38,450.61			6,948.18		14,651.13	60,049.92
New Jersey	634,069.41	287,861.51				7,670.48	929,601.40
New Mexico	131,512.50			54,940.20		59,842.41	246,295.11

New York:							
Cornell	1,672,627.75			355,256.21	6,688.51		2,034,572.47
State	725,940.06			29,314.05			755,254.11
North Carolina	738,249.84				133,485.73		871,735.57
North Dakota	345,509.38	22,354.76		122,446.92		72,828.95	563,140.01
Ohio	327,828.29			217,893.55		1,423,519.37	1,969,241.21
Oklahoma	733,633.00	58,256.66		254,426.88		107,673.67	1,153,990.21
Oregon	707,709.80	52,182.35	154,899.19	150,298.05			1,065,089.39
Pennsylvania	452,970.96	123,669.92		141,004.55	234,258.22	64,025.19	1,015,928.84
Puerto Rico	550,120.57					87,946.86	638,067.43
Rhode Island	42,257.99	12,125.87		20,983.52		19,850.01	95,217.39
South Carolina	305,561.78	16,432.77		160,859.38		35,887.41	518,741.34
South Dakota	151,500.00	5,397.50		104,882.32		15,328.89	277,108.71
Tennessee	328,053.74	37,715.34		166,710.51			532,479.59
Texas	934,358.33	52,150.70		787,389.56	115,150.76	654,727.51	2,543,776.86
Utah	290,000.00	44,776.89		45,426.98	1,459.73	19,919.19	401,582.79
Vermont	53,000.00			2,636.53	19,102.31	7,803.80	82,542.64
Virginia	590,816.67			69,893.12		19,112.40	679,822.19
Washington	1,128,882.58	96,738.75		223,849.77			1,449,471.10
West Virginia	95,500.00	9,723.25		150,939.58		47,033.44	303,196.27
Wisconsin	1,028,018.00	463,676.00		331,700.00			1,823,394.00
Wyoming	209,887.93	281.80		111,329.10		54,655.10	376,153.93
Total	28,146,471.73	2,405,468.64	700,480.48	7,879,152.32	993,166.42	5,570,060.08	45,694,799.67

TABLE 4.—*Expenditures and appropriations under the Hatch Act (Mar. 2, 1887)*[1] *for the year ended June 30, 1949*

Station	Expenditures												Unexpended	Appropriation
	Personal Services	Travel	Transportation of things	Communication service	Rents and utility services	Printing and binding	Other contractual services	Supplies and materials	Equipment	Lands and structures (contractual)	Contributions to retirement	Total expenditures		
Alabama	$13,732.04	$118.51	$75.19	$234.85	$51.70		$24.12	$663.84	$99.75			$15,000.00		$15,000
Arizona	14,391.66	27.72		22.00	301.03		100.00	157.59				15,000.00		15,000
Arkansas	10,519.09	96.12	10.81		50.00	$2,076.72		1,444.40	598.53	$6.00	$198.33	15,000.00		15,000
California	15,000.00											15,000.00		15,000
Colorado	12,102.42	636.48		43.47		412.22	1,187.65	201.26	15.00		401.50	15,000.00		15,000
Connecticut:														
State				1,630.82	3,268.30	1,019.00	50.23	1,530.43				7,498.78	$1.22	7,500
Storrs	4,904.81	160.91	8.48			291.86		257.05	1,876.89			7,500.00		7,500
Delaware	12,246.20	343.71	15.76	1,054.95		145.00	83.11	670.11	441.16			15,000.00		15,000
Florida	15,000.00											15,000.00		15,000
Georgia	11,015.15	227.25	7.49	1.23		1,815.55	5.00	1,155.14	773.19			15,000.00		15,000
Hawaii	14,050.00								950.00			15,000.00		15,000
Idaho	7,047.48	2,045.20	27.49	280.57		3,662.94	119.68	1,670.04	146.60			15,000.00		15,000
Illinois	14,615.19										384.81	15,000.00		15,000
Indiana	15,000.00											15,000.00		15,000
Iowa	15,000.00											15,000.00		15,000
Kansas	13,938.27	276.97		25.53	4.50		89.05	398.24	267.44			15,000.00		15,000
Kentucky	14,479.27					463.34		57.39				15,000.00		15,000
Louisiana	13,534.97	97.15		60.12		13.04	526.67	158.95	609.10			15,000.00		15,000
Maine	11,942.12	316.92	93.45	245.74	545.91	186.00	94.07	1,105.18	470.61			15,000.00		15,000
Maryland	7,500.00	3,908.70		3.75		241.27		3,104.13	108.73			14,866.58	133.42	15,000
Massachusetts	7,891.69	1,341.20				2,937.02	155.00	1,577.65	1,097.44			15,000.00		15,000
Michigan	5,903.31					9,096.69						15,000.00		15,000
Minnesota	10,148.08	1,323.53	29.27	161.77	121.80		38.05	1,739.57	1,196.53		241.40	15,000.00		15,000
Mississippi	11,631.39	345.21	7.03	643.46	59.57		295.21	1,717.89	300.24			15,000.00		15,000
Missouri	11,826.50	186.40		18.83	66.85		114.85	1,054.05	1,376.61	110.08	245.83	15,000.00		15,000
Montana	11,472.72	291.38	13.15	25.01		1,898.90	148.86	902.09	247.89			15,000.00		15,000
Nebraska	15,000.00											15,000.00		15,000
Nevada	13,369.70	387.50	5.67	250.25	117.52	196.35	95.75	261.26			316.00	15,000.00		15,000
New Hampshire	13,409.56	88.12		182.43	1,000.00	125.01	74.05	64.09	56.74			15,000.00		15,000

New Jersey	13,429.75			53.12	432.00		32.35	337.54	715.24			15,000.00		15,000
New Mexico	12,812.80	367.67	25.05	12.22	107.74	842.53	229.62	360.60	241.77			15,000.00		15,000
New York:														
Cornell	10,269.62						121.95	1,339.46	1,763.40			13,494.43	5.57	13,500
State	1,499.02											1,499.02	.98	1,500
North Carolina	11,197.24	774.96	17.04	100.00		794.02	549.91	1,147.57	419.26			15,000.00		15,000
North Dakota	14,040.57		1.77	69.92		114.15		229.59			544.00	15,000.00		15,000
Ohio	13,148.26	1,007.05	.99			90.00	20.19	627.85	105.66			15,000.00		15,000
Oklahoma	5,197.40	1,278.41	179.73		15.93	20.36	1,175.99	5,335.52	1,796.66			15,000.00		15,000
Oregon	11,818.91	2,883.59						.50	297.00			15,000.00		15,000
Pennsylvania	11,669.84	157.13				2,441.55	70.56	361.24	299.68			15,000.00		15,000
Puerto Rico	11,944.91	1,217.84		113.84				932.36	791.05			15,000.00		15,000
Rhode Island	7,211.38	386.73	10.78	1,041.98		2,111.96	262.18	1,572.35	2,402.64			15,000.00		15,000
South Carolina	12,312.97	27.85	2.50	344.35		829.92	461.86	653.79	366.76			15,000.00		15,000
South Dakota	12,162.85	1,121.47	9.53	27.87	8.00		553.31	901.36	215.61			15,000.00		15,000
Tennessee	15,000.00											15,000.00		15,000
Texas	10,128.55	1,683.78	13.80	399.79			1,819.38	677.85	276.85			15,000.00		15,000
Utah	15,000.00											15,000.00		15,000
Vermont	9,277.38	49.88	50.61	837.51	2,131.96	1,356.64	226.66	577.77	241.30		141.75	14,891.46	108.54	15,000
Virginia	14,962.09							37.91				15,000.00		15,000
Washington	12,772.67	351.47					558.72	687.57	316.50		313.07	15,000.00		15,000
West Virginia	13,775.00	136.34		9.30		109.42	23.88	710.83	235.23			15,000.00		15,000
Wisconsin	9,539.29	53.88	413.27				696.91	3,961.28	335.37			15,000.00		15,000
Wyoming	12,683.57	300.00				2,016.43						15,000.00		15,000
Total	598,525.69	24,017.03	1,018.86	7,894.68	8,282.81	35,307.89	10,004.82	40,343.29	21,452.43	116.08	2,786.69	749,750.27	249.73	750,000

[1] Extended to Hawaii by act of May 16, 1928, and to Puerto Rico by act of March 4, 1931.

TABLE 5.—*Expenditures and appropriations under the Adams Act (Mar. 16, 1906)*[1] *for the year ended June 30, 1949*

Station	Expenditures											Unexpended	Appropriation
	Personal services	Travel	Transportation of things	Communication service	Rents and utility services	Other contractual services	Supplies and materials	Equipment	Lands and structures (contractual)	Contributions to retirement	Total expenditures		
Alabama	$11,927.15	$16.15	$21.47	$6.88	$852.14	-------	$589.63	$935.00	$651.58	-------	$15,000.00	-------	$15,000
Arizona	12,574.82	1,142.60	107.76	78.56	-------	$283.66	812.60	-------	-------	-------	15,000.00	-------	15,000
Arkansas	12,362.45	532.91	-------	-------	137.50	34.62	705.34	683.43	-------	$543.75	15,000.00	-------	15,000
California	15,000.00	-------	-------	-------	-------	-------	-------	-------	-------	-------	15,000.00	-------	15,000
Colorado	12,048.30	250.74	336.48	6.25	394.81	80.11	1,128.49	557.86	-------	196.96	15,000.00	-------	15,000
Connecticut:													
State	6,582.50	53.22	-------	-------	-------	199.90	663.70	-------	-------	-------	7,499.32	$0.68	7,500
Storrs	7,500.00	-------	-------	-------	-------	-------	-------	-------	-------	-------	7,500.00	-------	7,500
Delaware	10,550.57	359.98	7.34	2.75	108.01	120.72	538.06	2,760.52	-------	-------	14,447.95	552.05	15,000
Florida	15,000.00	-------	-------	-------	-------	-------	-------	-------	-------	-------	15,000.00	-------	15,000
Georgia	13,261.69	1.00	1.03	.86	-------	281.00	749.86	704.56	-------	-------	15,000.00	-------	15,000
Hawaii	13,947.11	-------	2.61	-------	-------	-------	164.44	771.75	-------	-------	14,885.91	114.09	15,000
Idaho	12,507.30	343.34	7.11	19.03	5.60	665.98	1,069.83	381.81	-------	-------	15,000.00	-------	15,000
Illinois	10,784.79	-------	53.46	-------	-------	-------	1,176.16	2,652.58	-------	333.01	15,000.00	-------	15,000
Indiana	13,972.89	-------	-------	-------	-------	-------	1,015.26	6.38	-------	-------	14,994.53	5.47	15,000
Iowa	15,000.00	-------	-------	-------	-------	-------	-------	-------	-------	-------	15,000.00	-------	15,000
Kansas	13,110.81	-------	-------	-------	-------	48.55	1,378.33	462.31	-------	-------	15,000.00	-------	15,000
Kentucky	15,000.00	-------	-------	-------	-------	-------	-------	-------	-------	-------	15,000.00	-------	15,000
Louisiana	13,084.77	801.32	14.42	-------	-------	15.45	894.12	133.50	56.42	-------	15,000.00	-------	15,000
Maine	14,297.77	75.80	-------	-------	-------	9.55	614.96	1.92	-------	-------	15,000.00	-------	15,000
Maryland	12,507.50	-------	-------	-------	-------	-------	1,067.42	1,425.08	-------	-------	15,000.00	-------	15,000
Massachusetts	15,000.00	-------	-------	-------	-------	-------	-------	-------	-------	-------	15,000.00	-------	15,000
Michigan	15,000.00	-------	-------	-------	-------	-------	-------	-------	-------	-------	15,000.00	-------	15,000
Minnesota	13,533.09	711.46	73.49	-------	-------	-------	272.10	112.41	-------	297.45	15,000.00	-------	15,000
Mississippi	12,451.29	186.80	135.21	87.19	259.31	547.01	846.40	285.24	201.55	-------	15,000.00	-------	15,000
Missouri	11,864.70	6.77	25.89	2.00	38.67	513.18	2,068.20	303.51	-------	177.08	15,000.00	-------	15,000
Montana	12,985.22	390.71	23.17	2.06	-------	356.36	765.42	477.06	-------	-------	15,000.00	-------	15,000
Nebraska	15,000.00	-------	-------	-------	-------	-------	-------	-------	-------	-------	15,000.00	-------	15,000
Nevada	11,224.49	166.63	-------	5.63	-------	-------	3,153.00	8.50	-------	441.75	15,000.00	-------	15,000
New Hampshire	14,033.11	89.82	7.76	9.45	-------	257.51	317.25	285.10	-------	-------	15,000.00	-------	15,000

New Jersey	13,288.56	74.06	27.02			29.97	1,392.89	187.50			15,000.00		15,000
New Mexico	12,839.04	28.82	8.88	1.76	293.10	231.43	915.65	681.32			15,000.00		15,000
New York:													
Cornell	8,818.39	13.30	3.09			595.12	1,733.62	2,336.48			13,500.00		13,500
State	501.03						199.88	782.90			1,483.81	16.19	1,500
North Carolina	11,371.15	134.71				1,393.46	639.43	1,461.25			15,000.00		15,000
North Dakota	14,439.40		7.00	1.52		32.66	50.77			468.65	15,000.00		15,000
Ohio	13,184.59						1,368.43	446.98			15,000.00		15,000
Oklahoma	8,208.21	366.72	13.90			447.00	3,267.71	2,696.46			15,000.00		15,000
Oregon	14,870.25	13.86		2.74			113.15				15,000.00		15,000
Pennsylvania	15,000.00										15,000.00		15,000
Puerto Rico	11,168.51	333.08	15.60		12.00	355.57	1,959.96	1,155.28			15,000.00		15,000
Rhode Island	12,269.96	233.47	1.01			12.68	1,694.28	788.60			15,000.00		15,000
South Carolina	13,053.87	414.00	7.04	53.59	170.18	75.76	777.42	448.14			15,000.00		15,000
South Dakota	11,942.33	553.71	11.73	7.80	170.00	13.75	1,142.93	1,157.75			15,000.00		15,000
Tennessee	14,045.21				7.88	45.40	615.32	286.19			15,000.00		15,000
Texas	12,860.47	13.05		4.69		60.76	360.72	1,656.31		44.00	15,000.00		15,000
Utah	15,000.00										15,000.00		15,000
Vermont	12,231.17	200.81	15.25	4.76	.66	232.31	851.93	930.76		532.35	15,000.00		15,000
Virginia	13,545.55	356.22	4.04	28.80	170.43	222.03	672.93				15,000.00		15,000
Washington	10,311.11	580.38	11.87	3.18		248.27	1,779.68	1,103.08		319.75	14,357.32	642.68	15,000
West Virginia	13,500.00					18.40	957.26	524.34			15,000.00		15,000
Wisconsin	10,991.63						4,008.37				15,000.00		15,000
Wyoming	13,166.69	480.35					847.78	505.18			15,000.00		15,000
Total	648,719.44	8,925.79	943.63	329.50	2,620.29	7,428.17	45,340.68	30,097.04	909.55	3,354.75	748,668.84	1,331.16	750,000

[1] Extended to Hawaii by act of May 16, 1928, and to Puerto Rico by act of March 4, 1931.

TABLE 6.—*Expenditures and appropriations under the Purnell Act (Feb. 24, 1925)*[1] *for the year ended June 30, 1949*

Station	Expenditures												Unexpended	Appropriation
	Personal services	Travel	Transportation of things	Communication service	Rents and utility services	Printing and binding	Other contractual services	Supplies and materials	Equipment	Lands and structures (contractual)	Contributions to retirement	Total expenditures		
Alabama	$47,756.96	$943.89	$44.53	$210.62	$1,594.75	$1,242.15	$524.52	$3,913.89	$2,026.21	$1,742.48		$60,000.00		$60,000
Arizona	42,512.08	2,244.56	291.15	162.76	64.00	2,266.66	316.64	9,404.55	2,405.08	332.52		60,000.00		60,000
Arkansas	39,871.63	2,420.46		17.48	968.87	36.25	650.15	5,959.32	8,266.99		$1,063.35	59,254.50	$745.50	60,000
California	60,000.00											60,000.00		60,000
Colorado	48,426.41	1,292.08	3.16	105.00	561.16	123.54	1,625.46	3,930.74	1,378.05	1,268.71	1,285.69	60,000.00		60,000
Connecticut:														
State	20,715.83	157.28				2,146.93	1,181.48	1,105.93	2,181.04	2,467.19		29,955.68	44.32	30,000
Storrs	25,311.84	449.33					99.30	1,311.22	2,828.31			30,000.00		30,000
Delaware	44,605.00	2,187.63	38.45	24.26	740.25	659.45	767.75	7,668.86	3,308.35			60,000.00		60,000
Florida	60,000.00											60,000.00		60,000
Georgia	50,741.86	1,566.39	86.47	1.93	168.00	943.40	914.70	4,350.04	1,227.21			60,000.00		60,000
Hawaii	52,240.43		11.24				2,010.63	757.86	4,979.84			60,000.00		60,000
Idaho	40,504.17	3,091.94	148.26	341.31	86.33		432.84	10,907.55	4,425.39	62.21		60,000.00		60,000
Illinois	47,847.38	1,450.74	10.01	2.60		790.13	2,296.36	5,141.24	1,413.64		1,047.90	60,000.00		60,000
Indiana	54,339.73	1,445.31	11.92	22.44			382.46	1,570.72	1,119.22			58,891.80	1,108.20	60,000
Iowa	60,000.00											60,000.00		60,000
Kansas	56,843.59	605.42	2.84	4.25	45.43		318.29	1,720.08	460.10			60,000.00		60,000
Kentucky	48,248.70	3,265.69	38.34	9.86		5,793.55	61.70	1,394.05	1,188.11			60,000.00		60,000
Louisiana	45,048.52	1,747.40	174.37	58.20	449.49	320.46	1,494.18	6,592.16	3,995.78	119.44		60,000.00		60,000
Maine	44,020.79	1,468.87	28.14	32.75	1,165.31	271.59	510.84	11,071.34	1,430.37			60,000.00		60,000
Maryland	53,437.42		90.31		25.33		1,171.10	2,126.99	3,128.12			59,979.27	20.73	60,000
Massachusetts	50,459.17	1,447.43					452.55	3,546.66	4,066.75	27.44		60,000.00		60,000
Michigan	58,418.02	40.84						46.44	1,494.70			60,000.00		60,000
Minnesota	50,241.92	1,192.26	112.75	214.60		935.98	925.29	3,334.01	1,945.90	533.20	564.09	60,000.00		60,000
Mississippi	40,597.57	845.86	403.93	323.86	482.21	2,160.14	1,084.79	6,339.67	5,479.82	2,282.15		60,000.00		60,000
Missouri	45,069.71	1,180.39	80.70	47.11	109.60	1,101.14	670.71	6,724.51	3,998.04		1,018.09	60,000.00		60,000
Montana	51,385.11	1,551.87	51.11	171.17	231.98	230.00	776.28	3,075.29	2,527.19			60,000.00		60,000
Nebraska	54,694.51	1,168.12					210.36	3,094.12	832.89			60,000.00		60,000
Nevada	42,351.53	1,010.88	322.06	321.20	214.60	31.55	306.17	11,994.73	2,349.78		1,097.50	60,000.00		60,000
New Hampshire	58,261.45	340.70	11.09	16.25	95.00	16.59	172.39	862.78	223.75			60,000.00		60,000

New Jersey	51,835.07	1,226.73	39.14		489.00	20.79	669.77	4,482.57	1,236.93			60,000.00		60,000
New Mexico	48,895.73	1,654.84	163.71	115.98	1,154.78	749.00	875.20	4,730.78	1,659.98			60,000.00		60,000
New York:														
Cornell	45,926.62	1,981.70	35.86	83.59	261.56		1,207.70	1,800.14	2,642.51			53,939.68	60.32	54,000
State	5,103.77				50.00		62.51	298.07	485.65			6,000.00		6,000
North Carolina	47,299.44	3,770.46	36.97	327.62	11.25	136.00	272.15	5,170.30	2,975.81			60,000.00		60,000
North Dakota	55,788.04	225.63	4.28	25.17	105.06	216.47	143.85	765.31	774.43	3.60	1,948.16	60,000.00		60,000
Ohio	51,097.76	1,330.72	15.58		126.20		43.53	2,876.43	4,509.78			60,000.00		60,000
Oklahoma	38,920.31	2,036.64	188.04		1,310.00	15.35	1,515.66	8,950.16	6,775.51	288.33		60,000.00		60,000
Oregon	54,090.09	1,211.60		32.60	42.90		119.65	1,285.01	3,218.15			60,000.00		60,000
Pennsylvania	54,313.94	1,038.96				2,286.74	262.78	172.58		1,925.00		60,000.00		60,000
Puerto Rico	40,941.19	770.47	4.38		40.00	1,289.70	660.87	3,184.24	11,772.35			58,663.20	1,336.80	60,000
Rhode Island	51,072.41	335.24	16.19			795.50	142.05	4,892.96	2,745.65			60,000.00		60,000
South Carolina	50,746.06	1,464.74	11.62	167.83	207.49	1,410.76	1,341.42	2,771.60	1,878.47			60,000.00		60,000
South Dakota	42,910.17	2,010.24	94 45	66.45	242.80	1,136.83	528.19	7,502.62	5,508.25			60,000.00		60,000
Tennessee	57,496.36	224.21	31.46	3.50	103.99		70.24	1,515.52	554.72			60,000.00		60,000
Texas	51,140.94	305.87	41.67	204.47	60.00	48.51	466.35	3,316.40	3,746.32	617.22	52.20	59,999.95	0.05	60,000
Utah	53,317.43	2,570.57	54.21			35.50	534.87	2,066.77	1,420.65			60,000.00		60,000
Vermont	46,415.88	2,569.9.	44.54	17.85	110.62	7.29	1,005.34	2,835.88	4,709.38	864.13	944.03	59,524.84	475.16	60,000
Virginia	56,164.07	992.78	1.15		265.20		165.12	1,805.29	606.39			60,000.00		60,000
Washington	42,127.07	2,190.48	57.87	31.09	16.00	847.61	1,202.87	6,513.62	5,843.42		955.86	59,785.89	214.11	60,000
West Virginia	50,483.65	1,056.29	2.23		1,363.70	513.42	11.11	5,572.56	997.04			60,000.00		60,000
Wisconsin	54,637.52	943.79	23.68	5.78			57.90	2,973.43	1,357.90			60,000.00		60,000
Wyoming	56,235.32	2,179.99	7.32			400.00		710.16	467.21			60,000.00		60,000
Total	2,500,910.17	35,207.19	2,835.19	3,169.58	12,962.86	28,978.98	30,716.07	194,137.15	134,567.13	12,533.62	9,976.87	2,995,994.81	4,005.19	3,000,000

[1] Extended to Hawaii by act of May 16, 1928, and to Puerto Rico by act of Mar. 4, 1931.

TABLE 7.—*Expenditures and appropriations under the Bankhead-Jones Act (June 29, 1935) for the year ended June 30, 1949*

Station	Expenditures												Unexpended	Appropriation
	Personal services	Travel	Transportation of things	Communication service	Rents and utility services	Printing and binding	Other contractual services	Supplies and materials	Equipment	Lands and structures (contractual)	Contributions to retirement	Total expenditures		
Alabama	$70,193.36	$1,789.70	$137.45	$145.16	$1,514.07	$2,349.40	$851.23	$12,698.85	$2,117.61	$4,355.98		$96,152.81		$96,152.81
Arizona	10,687.79	600.98	31.35	98.15		987.50	153.57	804.40	2,003.32	132.30		15,499.36		15,499.36
Arkansas	51,192.10	2,541.01	17.75		600.72	1,742.30	1,521.21	2,809.42	12,629.99		$1,127.33	74,181.83	$130.93	74,312.76
California	95,129.38								413.23			95,542.61		95,542.61
Colorado	20,766.35	751.84		18.16	63.28		333.98	1,381.18	2,287.17		454.02	26,055.98		26,055.98
Connecticut:														
State	9,535.00	146.14					259.37	184.93	1,024.02	1,513.00		12,662.46	466.82	13,129.28
Storrs	9,505.00							2,797.39	826.89			13,129.28		13,129.28
Delaware	4,146.14						173.00	1,606.04	129.76			6,054.94		6,054.94
Florida	29,802.02	299.71	209.29	2.90			.75	3,127.99	7,136.56			40,579.22		40,579.22
Georgia	81,013.92	1,966.92	99.66	3.39	133.68	323.25	507.34	14,401.16	3,027.48			101,476.80		101,476.80
Hawaii	7,463.93		1.96					892.18	1,911.32			10,269.39		10,269.39
Idaho	12,232.10	294.72	79.15	32.23			310.23	1,408.65	1,691.81	540.92		16,589.81		16,589.81
Illinois	87,291.40	2,144.22	58.85	8.16		37.57	1,823.87	5,784.03	987.25		2,811.52	100,946.87		100,946.87
Indiana	65,238.96	733.53	16.20	17.36	238.00		861.79	4,639.13	1,638.91			73,383.88		73,383.88
Iowa	74,752.37											74,752.37		74,752.37
Kansas	51,132.05	279.86			249.75	276.56		3,553.76	1,686.56			57,178.54		57,178.54
Kentucky	78,245.22	2,595.61	76.97	7.85		2,099.10	150.08	9,297.31	2,650.11			95,122.25		95,122.25
Louisiana	41,987.80	2,240.93	79.37	18.75		1,350.62	1,033.46	5,463.06	11,701.25	2,044.72		65,919.96		65,919.96
Maine	20,192.00	818.75	16.03	20.50	40.60	568.62	350.92	1,243.71	806.92	66.00		24,124.05		24,124.05
Maryland	31,850.67		1.61		9.68			2,898.86	542.19			35,303.01		35,303.01
Massachusetts	21,693.39								94.00			21,787.39		21,787.39
Michigan	77,264.03	210.28	38.25	.50		1,240.43	651.41	5,197.59	1,225.24			85,827.73		85,827.73
Minnesota	47,004.92	2,269.19	414.92	96.92	52.48	675.52	1,569.91	8,233.54	5,832.90	380.05	283.56	66,813.91		66,813.91
Mississippi	51,023.71	2,710.76	276.94	524.79	1,201.69	251.84	1,697.76	14,182.12	10,640.03	2,060.34		84,569.98		84,569.98
Missouri	60,531.25	1,278.76	114.00	259.17	878.98	1,826.97	1,612.77	18,087.70	3,680.24		1,113.79	89,383.63		89,383.63
Montana	15,305.06	145.05	149.25	50.43	22.51		143.34	2,029.58	26.24			17,871.46		17,871.46
Nebraska	41,829.72	524.89	5.30	1.75		3.00	1,053.46	815.60				44,233.72		44,233.72
Nevada	3,120.00	43.50		2.51				9.39			15.00	3,190.40		3,190.40
New Hampshire	6,893.66	463.47	14.49	5.30			96.43	507.05	1,944.90			9,925.30		9,925.30

New Jersey	29,650.33	771.24	1.73		138.00	14.50	355.49	3,683.51	1,473.12	382.45		36,470.37		36,470.37
New Mexico	10,804.75	114.55		7.44	150.73		711.53	5,076.36	70.00			16,935.36		16,935.36
New York:														
Cornell	68,857.53	1,411.58	19.32	5.75	1,876.00		2,399.39	13,825.03	10,805.98			99,200.58	1.59	99,202.17
State	8,286.40						97.15	771.89	1,794.87			10,950.31	72.15	11,022.46
North Carolina	98,276.76	4,325.19	321.29	424.42	436.38	284.47	3,169.87	10,071.64	4,346.49	2,110.00		123,766.51		123,766.51
North Dakota	25,159.27	40.90	49.78	6.05			173.93	1,662.54	143.45		911.50	28,147.42		28,147.42
Ohio	85,201.50	896.70	23.49			213.45	314.81	8,475.18	14,211.24			109,336.37	.89	109,337.26
Oklahoma	49,473.63	1,402.02	328.96		177.73	30.44	3,114.95	14,824.39	5,614.30	3,394.74		78,361.16	6.00	78,367.16
Oregon	20,374.49	74.93		45.13	115.40		71.93	784.71	5,122.13			26,588.72		26,588.72
Pennsylvania	124,622.98	3,204.60	6.08	27.60	249.00	2,833.34	110.20	6,302.65	7,429.41	13,090.62		157,876.48		157,876.48
Puerto Rico	40,171.47	1,032.51	156.72		1,771.81		124.00	14,986.68	3,356.91			61,600.10	482.04	62,082.14
Rhode Island	2,515.22	92.71	.73		150.00			98.53				2,857.19		2,857.19
South Carolina	54,214.04	175.71	45.86	114.47	731.01		1,622.07	6,482.95	3,838.08	2,000.00		69,224.19		69,224.19
South Dakota	17,437.73	823.61	32.76	53.34		135.96	383.22	6,385.41	2,480.98			27,733.01		27,733.01
Tennessee	77,422.68	406.21	56.70	18.24	94.44	294.72	687.87	6,799.27	4,193.96	18.00		89,992.09		89,992.09
Texas	140,029.40	3,348.84	102.21	204.05	249.82	75.69	3,789.99	12,213.79	10,921.15	2,249.13	28.35	173,212.42	.39	173,212.81
Utah	11,155.92	719.06	1.14			2.10	122.02	144.16	25.75			12,170.15		12,170.15
Vermont	9,090.74	125.93	8.65	37.90	116.37		469.92	955.47	948.30	24.99	256.00	12,034.27	43.74	12,078.01
Virginia	74,276.13	1,158.14	8.72	46.82	28.76	593.94	490.39	4,736.04	1,602.92			82,941.86		82,941.86
Washington	27,061.95	504.61	12.94	60.89			396.00	6,081.40	3,807.29		870.16	38,795.24	1.85	38,797.09
West Virginia	53,470.02	1,507.05			825.57	1,141.09	74.07	6,668.56	1,482.69			65,169.05		65,169.05
Wisconsin	52,918.29	79.98	28.24				1,069.47	15,200.93	855.68			70,152.59		70,152.59
Wyoming	6,920.00	343.89						286.06	279.41			7,829.36		7,829.36
Total	2,264,414.53	47,409.78	3,044.11	2,366.08	12,116.46	19,352.38	34,904.15	270,571.77	163,460.01	34,363.24	7,871.23	2,859,873.74	1,206.40	2,861,080.14

TABLE 8.—*Expenditures and funds available under the Research and Marketing Act of 1946, Title I, Sections 9 (b) (1) and 9 (b) (2), for the year ended June 30, 1949*

Station	Expenditures												Unexpended balances[1]	Funds available[2]
	Personal services	Travel	Transportation of things	Communication service	Rents and utility services	Printing and binding	Other contractual services	Supplies and materials	Equipment	Lands and structures (contractual)	Contributions to retirement	Total expenditures		
Alabama	$50,398.14	$5,950.99	$179.23	$198.34	$1,228.57	-------	$772.98	$5,918.01	$12,317.35	$2,376.44	-------	$79,340.05	$2,922.07	$82,262.12
Arizona	16,458.95	1,986.42	48.71	162.57	281.51	$17.65	334.72	2,189.39	2,509.67	468.95	-------	24,458.54	192.69	24,651.23
Arkansas	25,075.62	2,974.12	-------	166.44	533.99	-------	642.87	3,649.75	9,767.27	19,498.42	$121.25	62,429.73	16,024.93	78,454.66
California	48,842.11	-------	-------	-------	-------	-------	251.84	237.93	22,005.13	-------	-------	71,337.01	10,002.49	81,339.50
Colorado	22,224.45	673.01	52.25	79.73	76.21	15.25	950.36	1,068.05	807.30	-------	602.21	26,548.82	8,257.85	34,806.67
Connecticut:														
State	4,769.82	254.19	3.64	-------	-------	-------	208.59	1,373.60	8,619.25	755.45	-------	15,984.54	2,273.60	18,258.14
Storrs	7,262.55	336.71	-------	3.00	-------	-------	1,200.00	1,788.31	2,256.73	-------	-------	12,847.30	3,962.58	16,809.88
Delaware	11,436.78	1,151.06	65.75	2.24	-------	245.00	223.63	730.09	1,416.10	-------	-------	15,270.65	9,341.86	24,612.51
Florida	31,878.16	2,933.39	108.93	43.94	62.76	-------	534.77	2,242.85	6,396.17	-------	-------	44,200.97	2,308.83	46,509.80
Georgia	60,642.99	3,239.31	184.85	10.47	437.31	36.08	885.75	6,784.52	8,300.93	-------	-------	80,522.21	864.78	81,386.99
Hawaii	10,142.23	4,331.83	4.31	-------	31.00	4.16	-------	-------	4,708.95	-------	-------	19,222.48	9,302.89	28,525.37
Idaho	9,434.63	1,146.61	261.20	176.84	71.00	-------	308.14	8,255.95	4,756.49	2,268.52	-------	26,679.38	1,191.34	27,870.72
Illinois	41,108.07	1,985.03	41.19	-------	-------	311.26	1,261.94	17,654.97	6,003.41	-------	515.29	68,881.16	35,727.80	104,608.96
Indiana	49,299.14	2,014.28	70.57	2.32	5.00	-------	304.34	10,884.69	4,327.86	-------	-------	66,908.20	11,327.47	78,235.67
Iowa	58,426.74	-------	-------	-------	-------	-------	-------	-------	-------	7,766.20	-------	66,192.94	-------	66,192.94
Kansas	38,308.00	1,276.40	17.00	24.10	-------	7.64	365.46	4,423.64	2,187.59	-------	-------	46,609.83	320.71	46,930.54
Kentucky	56,605.03	5,634.02	47.28	96.19	-------	818.98	226.68	10,331.71	5,972.52	-------	-------	79,732.41	14,415.71	94,148.12
Louisiana	36,805.42	2,828.48	87.14	48.09	255.29	161.81	225.60	5,058.19	9,092.85	2,057.50	-------	56,620.37	20,858.50	77,478.87
Maine	15,914.12	2,826.42	9.94	92.76	230.76	784.16	60.31	906.94	860.93	-------	-------	21,686.34	3,000.00	24,686.34
Maryland	22,733.53	281.87	171.30	3.60	7.69	-------	2,616.35	4,927.73	189.14	2,937.60	-------	33,868.81	1,503.25	35,372.06
Massachusetts	11,903.03	2,337.30	39.35	8.50	-------	66.00	677.00	3,399.67	4,224.70	582.65	-------	23,238.20	-------	23,238.20
Michigan	44,727.10	2,889.20	143.59	547.20	42.00	967.58	3,920.63	5,477.72	10,247.29	-------	-------	68,962.31	7,271.05	76,233.36
Minnesota	35,084.38	2,835.89	137.22	41.85	43.60	7.00	882.24	6,552.17	7,508.50	-------	-------	53,092.85	36,314.34	89,407.19
Mississippi	47,261.75	3,077.59	294.50	498.82	605.68	65.40	2,208.94	6,265.55	5,564.93	575.26	-------	66,418.42	21,411.29	87,829.71
Missouri	52,079.74	2,592.82	300.40	116.23	295.15	154.16	4,022.76	7,642.96	10,665.06	703.78	783.03	79,356.09	5,009.01	84,365.10
Montana	18,745.35	546.37	64.31	33.40	-------	-------	197.06	2,616.45	1,934.90	-------	-------	24,137.84	1,138.22	25,276.06
Nebraska	30,510.86	2,279.88	-------	-------	-------	-------	459.85	3,628.35	4,053.98	-------	-------	40,932.92	2,858.14	43,791.06
Nevada	9,543.27	587.13	26.80	85.44	380.43	-------	21.23	2,126.77	1,055.09	69.16	234.75	14,130.07	-------	14,130.07
N. Hampshire	20,302.81	1,352.82	30.36	43.85	-------	30.55	961.05	1,421.95	1,359.95	-------	-------	25,503.34	-------	25,503.34

New Jersey	12,687.38	884.99	119.66				2,538.99	910.60	5,729.55	4,687.53		27,558.70		27,558.70
New Mexico	12,049.06	1,653.44	8.18	18.99	390.76		614.13	3,571.69	4,505.79			22,812.04	11,948.22	34,760.26
New York:														
Cornell	34,570.90	2,193.87	15.46	28.49	748.25	15.00	2,525.64	4,851.07	6,622.25			51,570.93	22,038.96	73,609.89
State	4,233.32	45.90					15.07	1,176.81	2,165.61			7,636.71	2,013.29	9,650.00
No. Carolina	64,319.46	3,060.11	123.62	310.48	44.13	101.94	1,708.67	8,943.88	16,879.16			95,491.45	14,760.11	110,251.56
North Dakota	19,763.99	2,512.63	8.83	16.20			418.01	4,396.74	407.06		534.75	28,058.21	2,362.03	30,420.24
Ohio	41,149.84	2,655.68	61.06		50.00	212.74		2,830.84	5,131.56			52,091.72	59,733.87	111,825.59
Oklahoma	32,941.33	1,994.94	23.11		34.25	1.50	1,283.75	7,344.61	7,685.77	8,800.00		60,109.26	3,379.97	63,489.23
Oregon	21,907.55	2,651.06	79.11	48.24	90.00		56.56	1,059.87	2,983.00			28,875.39	6,967.28	35,842.67
Pennsylvania	52,652.36	4,888.68			11.00	175.00	254.20	1,510.82	23,159.83	11,945.56		94,597.45		94,597.45
Puerto Rico	49,325.84	3,224.13	42.97		973.59		125.00	7,653.64	7,638.80			68,983.97	6,074.60	75,058.57
Rhode Island	12,276.00	57.70						4,372.04	9.00	25.00		16,739.74	984.37	17,724.11
South Carolina	29,432.69	4,157.76	158.94	174.89	124.26	147.03	3,219.90	5,073.67	5,402.50	2,000.00		49,891.64	13,099.39	62,991.03
South Dakota	15,188.58	687.65	119.62	10.48			1,127.11	4,787.20	6,529.81			28,450.45	4,858.18	33,308.63
Tennessee	60,327.87	3,679.35	187.65	25.78	58.49	33.89	924.95	6,872.81	9,529.70			81,640.49	528.88	82,169.37
Texas	88,188.84	7,349.56	174.10	628.80	223.12	1,679.25	3,950.42	11,342.16	22,005.96	11,197.74	6.40	146,746.35	2,206.20	148,952.55
Utah	14,792.53	190.62	6.31					3,200.86	1,592.45			19,782.77	135.99	19,918.76
Vermont	12,907.50	1,280.71	.99				74.76	1,363.94	492.42		144.24	16,264.56	7,198.80	23,463.36
Virginia	42,845.77	2,895.50	8.26	235.43	393.80	82.80	366.43	2,326.62	2,178.81			51,333.42	14,462.82	65,796.24
Washington	22,401.31	1,388.22	98.28	70.96	21.38		2,101.28	7,007.96	6,670.65	694.89	388.62	40,843.55	1,533.61	42,377.16
West Virginia	36,060.68	1,588.54			10.00		437.76	4,073.41	4,258.06			46,428.45	20,612.44	67,040.89
Wisconsin	30,064.66	1,508.48	46.65		10.00	2,232.07	391.53	11,561.26	11,776.11			57,590.76	8,586.46	66,177.22
Wyoming	11,264.21	1,009.38	32.58				478.20	460.43	4,712.10			17,956.90	9,400.71	27,357.61
Total	1,609,276.44	111,882.04	3,705.20	4,054.66	7,770.98	8,373.90	47,337.45	234,250.84	317,175.99	79,410.65	3,330.54	2,426,568.69	440,687.58	2,867,256.27

[1] These unexpended balances by provisions of Title I, sec. 9 (*a*) of the Research and Marketing Act remain available for expenditure during the fiscal year ending June 30, 1950.

[2] Include allotments from the appropriation for fiscal year 1949 plus unexpended balances of allotments from appropriation for fiscal year 1948.

TABLE 9.—*Expenditures and funds available under the Research and Marketing Act of 1946, Title I, section 9 (b) (3), for the year ended June 30, 1949*

Station	Expenditures												Unexpended balances [1]	Funds available [2]
	Personal services	Travel	Transportation of things	Communication service	Rents and utility services	Printing and binding	Other contractual services	Supplies and materials	Equipment	Lands and structures (contractual)	Contributions to retirement	Total expenditures		
Alabama	$10,282.37	$1,415.48	$9.64	$121.25	$138.74		$190.04	$469.98	$1,806.00			$14,433.50	$423.40	$14,856.90
Arizona	6,802.10	1,912.69	93.53	19.99			210.00	1,293.08	820.52			11,151.91		11,151.91
Arkansas	8,564.01	988.32	19.05		6.09		360.18	213.40	1,829.62		$20.00	12,000.67	3,717.83	15,718.50
California	25,385.75	5,104.86	41.74	360.39	327.36		2,366.32	4,045.59	429.70			38,061.71	7,664.78	45,726.49
Colorado	10,647.16	5,096.72	20.94	84.87	96.20	$33.74	1,658.45	3,000.80	6,735.10		82.38	27,456.36	4,651.54	32,107.90
Connecticut:														
State														
Storrs	4,707.80	129.03			5.00	30.00	33.88	366.15	301.14			5,573.00	576.93	6,149.93
Delaware	750.00											750.00	2,250.00	3,000.00
Florida	2,088.66	3,600.37						32.48				5,721.51	3,385.49	9,107.00
Georgia	17,124.11	676.53			48.00		3.50	795.86	318.75			18,966.75	1,337.79	20,304.54
Hawaii														
Idaho	11,383.09	1,724.78		44.42				3,012.85	282.80			16,447.94	52.06	16,500.00
Illinois	12,752.38	1,386.00	5.29	5.05			27.43	1,523.80	476.90		55.55	16,232.40	19,055.36	35,287.76
Indiana	13,105.76	1,924.17		36.27			203.47	542.75	344.75			16,157.17	13,497.20	29,654.37
Iowa	10,858.21	5,754.89	94.31	251.41		187.95		29,713.80	2,688.25	$22,757.06		72,305.88	5,785.98	78,091.86
Kansas	6,497.41	826.48	2.88	7.80			99.10	175.39	1,198.62			8,807.68	895.58	9,703.26
Kentucky	5,361.47	981.94	17.84	1.50		50.00		902.68	1,295.22			8,610.65	104.81	8,715.46
Louisiana	7,361.89	661.32	2.44	342.35			30.70	295.69	1,802.84			10,497.23	7,274.10	17,771.33
Maine	12,359.27	2,564.74	4.30	40.17	22.70	38.47	6.90	612.63	20.82			15,670.00		15,670.00
Maryland	5,650.08	327.47	74.04		24.77		215.77	3,430.84	932.68			10,655.65	1,449.79	12,105.44
Massachusetts	11,160.00	13.33						1,123.30	203.37			12,500.00		12,500.00
Michigan	11,129.09	1,339.69	87.54	50.20		75.94	219.20	1,542.79	1,302.45			15,746.90	6,675.50	22,422.40
Minnesota	11,636.11	3,598.40	13.97	44.55	161.21		257.46	4,256.26	1,040.25			21,008.21	8,466.12	29,474.33
Mississippi	28,460.23	2,374.76	3.95	5.00	1.00		808.45	97.27	69.43			31,820.09	4,050.48	35,870.57
Missouri	10,185.91	1,376.04	35.54	80.09	62.89	9.65	129.72	930.80	1,758.16	21.07	56.25	14,646.12	7,345.65	21,991.77
Montana	5,564.37	1,747.98					13.17	239.37	97.50			7,662.39	565.62	8,228.01
Nebraska	3,695.51	578.90	39.59	47.37			1,210.54	755.87	447.93			6,775.71	3,109.73	9,885.44
Nevada	860.51	1,157.14				14.00		28.35			40.00	2,100.00		2,100.00
New Hampshire	2,508.93				270.00		490.04	935.96				4,204.93		4,204.93

New Jersey	17,473.15	1,085.33	35.00					416.70	730.70	258.76		19,999.64	7,451.82	27,451.46
New Mexico	7,790.77	366.75	19.39	10.07	344.40		121.25	2,193.72	1,305.51			12,151.86	3,383.88	15,535.74
New York:														
Cornell	28,332.49	3,970.23	14.32	439.27	502.40		4,965.81	2,119.88	2,964.95			43,309.35	17,873.09	61,182.44
State														
North Carolina	22,476.76	3,016.28	14.83	20.00			1.75	992.10	3,583.33			30,105.05	7,044.01	37,149.06
North Dakota	749.95	238.22		55.56	19.04	27.16	50.00	87.58			20.00	1,247.51	2,676.37	3,923.88
Ohio	6,671.75	945.84						476.82	75.00			8,169.41	2,447.54	10,616.95
Oklahoma	617.00	629.15			45.00		183.90	1,881.89	1,496.35			4,853.29	6,501.63	11,354.92
Oregon	23,422.93	8,546.83	110.47	230.59	55.56	1.40	1,618.99	2,008.84	1,739.86			37,735.47	5,330.42	43,065.89
Pennsylvania	3,895.00	2,013.47						1,694.22	4,638.82			12,241.51	5,090.57	17,332.08
Puerto Rico	2,760.81							602.54	136.65			3,500.00		3,500.00
Rhode Island	9,046.17	581.00	2.68				300.00	1,758.26	70.93			11,759.04	1,196.45	12,955.49
South Carolina	16,690.07	2,135.44	7.27	83.62	333.33		61.16	1,909.88	2,017.36			23,238.13	675.42	23,913.55
South Dakota	4,919.25	247.98					150.00	1,227.31	1,954.16			8,498.70	3,846.30	12,345.00
Tennessee	9,646.61	1,080.44	25.75	40.73			507.61	110.67	1,193.35			12,605.16	380.40	12,985.56
Texas	29,174.57	2,528.44	130.98	548.25	35.32		294.79	1,564.01	13,268.41	10,259.99		57,804.76	508.98	58,313.74
Utah	12,892.59	2,801.14	21.76	16.11		54.95	87.03	1,043.96	2,864.78	5,809.83		25,592.15	6,476.76	32,068.91
Vermont	973.95	217.17	7.18				37.92	1,277.71	201.93			2,715.86	137.17	2,853.03
Virginia	7,007.50	3,490.79	5.23		129.60		79.12	476.66	131.10			11,320.00		11,320.00
Washington	14,958.04	3,874.57	118.13	75.92		4,194.43		4,369.06	553.80	422.05	35.77	28,601.77	2,154.73	30,756.50
West Virginia	6,397.74	1,884.25				66.52	22.00	277.38	456.95			9,104.84	2,495.45	11,600.29
Wisconsin	12,290.05	2,274.37	197.73		36.00	643.07	1,113.47	3,138.67	4,520.81			24,214.17	2,555.90	26,770.07
Wyoming	4,285.53	3,435.21		27.33			36.08	40.93	243.75			8,068.83	3,280.91	11,349.74
Total	499,354.86	92,624.93	1,277.31	3,090.13	2,664.61	5,427.28	18,165.20	90,006.53	70,351.30	39,528.76	309.95	822,800.86	183,843.54	1,006,644.40

[1] These unexpended balances by provisions of Title I, sec. 9 (*a*) of the Research and Marketing Act remain available for expenditure during the fiscal year ending June 30, 1950.

[2] Include allotments from the appropriation for fiscal year 1949 plus unexpended balances of allotments from appropriation for fiscal year 1948.

TABLE 10.—*Expenditures from non-Federal funds for the year ended June 30, 1949*

Station	Personal services	Travel	Transportation of things	Communication service	Rents and utility services	Printing and binding	Other contractual services	Supplies and materials	Equipment	Lands and structures (contractual)	Contributions to retirement	Total	Unexpended balances
Alabama	$426,418.45	$20,541.85	$4,648.55	$3,848.44	$10,837.12	$286.52	$111,748.94	$231,762.97	$75,876.99	$43,903.02		$929,872.85	$274,277.62
Arizona	208,915.52	9,477.71	5,800.50	7,681.45	14,202.71	9,250.73	10,210.64	30,900.39	47,486.59			343,926.24	
Arkansas	246,745.16	15,625.32	2,625.71	2,451.43	12,209.37	421.54	13,432.85	94,860.50	56,644.75		$3,074.01	448,090.64	46,007.42
California	2,939,261.50	105,784.98	10,716.41	23,546.80	35,830.62	39,107.71	155,129.67	319,275.39	214,595.07			3,843,248.15	144,043.32
Colorado	208,391.24	11,312.59	2,370.91	3,446.66	10,826.22	2,770.36	12,066.44	76,614.47	55,147.74	10,687.91	3,341.26	396,975.80	89,757.27
Connecticut:													
State	237,195.46	1,468.17	138.29	1,028.94	2,995.16	5,051.45	11,381.64	23,283.91	27,880.45	14,337.05		324,760.52	14,415.46
Storrs	146,903.77	2,616.55	130.93	47.96	5.19	35.77	1,879.65	33,335.11	7,323.45	108,372.00		300,650.38	10,506.43
Delaware	69,840.16	2,727.99	798.78	2,003.16	3,724.28	585.03	6,041.30	62,457.84	6,626.46			154,805.00	29,621.08
Florida	1,270,317.90	53,980.74	4,982.54	10,617.20	26,255.19	16,487.49	51,635.09	344,574.54	127,024.40	272,542.51		2,178,417.60	379,988.33
Georgia	151,477.93	7,428.40	601.34	2,824.42	7,742.56	3,017.80	18,058.64	54,626.91	19,415.87	15,539.91		280,733.78	78,458.22
Hawaii	352,733.94	6,813.96	1,098.97	2,381.31	6,958.13	6,814.56	14,463.59	48,172.07	17,564.54	6,506.00		463,507.07	1,813.30
Idaho	177,442.47	8,400.00	660.00	1,340.00	1,150.00	700.00	880.00	53,146.12	33,219.47	24,940.00		301,878.06	43,269.82
Illinois	1,024,440.59	65,000.00		22,000.00		44,000.00		320,526.67	149,504.07	21,316.71		1,646,788.04	
Indiana	756,075.91	32,466.75	9,108.79	10,087.41	21,150.67	11,819.19	82,423.62	404,526.55	174,006.99	14,468.73		1,516,134.61	553,595.84
Iowa	613,050.21	42,225.98	4,010.08	4,760.73		26,288.69		402,652.50	38,003.55			1,130,991.74	306,818.43
Kansas	279,794.37	6,607.78	2,157.34	2,563.37	5,559.41	277.79	28,672.44	81,489.45	78,936.17	40,751.29		526,809.41	81,140.17
Kentucky	338,035.95	8,460.09	1,118.01	4,060.34	15,154.52	2,483.11	33,642.33	60,372.53	21,357.83			484,684.71	
Louisiana	533,799.28	31,946.79	3,152.96	5,259.26	9,908.32	3,480.97	52,532.42	158,912.19	103,305.42	124,542.62		1,026,840.23	
Maine	164,002.50	10,579.16	1,352.53	1,942.16	4,705.36	5,217.55	12,008.83	33,883.00	18,522.67	15,750.29		267,964.05	35,459.33
Maryland	176,959.85	8,330.35	613.17	935.34	650.57	1,909.19	10,351.04	83,928.38	32,033.35	3,245.32		318,956.56	70,659.89
Massachusetts	311,069.98	7,495.21	681.82	2,825.54	1,676.02	4,230.07	2,491.78	30,949.68	10,191.43	530.30		372,141.83	31,447.16
Michigan	533,529.67	24,428.13	1,468.06	1,973.94	2,182.95	21,124.80	25,602.04	76,320.39	34,116.67			720,746.65	75,677.81
Minnesota	934,217.14	19,608.58	7,259.77	8,526.51	22,418.52	4,496.23	101,315.95	227,870.19	83,954.26	15,378.80		1,425,045.95	
Mississippi	487,688.97	18,861.37	9,617.10	5,580.60	13,181.44	10,260.59	129,228.76	223,131.73	122,028.05	207,883.33		1,227,461.94	133,969.65
Missouri	210,184.08	11,649.76	2,486.32	2,651.84	10,049.94	22,130.79	23,607.76	97,249.49	51,943.69	19,439.03		451,392.70	250,845.27
Montana	279,462.57	9,726.94	3,746.18	3,921.68	21,539.18	3,844.56	12,142.36	125,535.28	73,319.37	53,304.97	6,520.00	593,063.09	257,304.02
Nebraska	312,058.68	25,515.95	3,853.93	2,869.97	9,237.52	3,985.81	5,834.31	172,860.28	120,598.86			656,815.31	
Nevada	14,759.85	3,285.43	499.53	653.12	2,658.72	645.35	2,383.46	18,670.43	8,536.18	2,988.65		55,080.72	11,487.72
New Hampshire	33,601.02	4,071.55	191.99	539.33		1,229.55	792.61	7,065.39	5,273.25			52,764.69	7,285.23
New Jersey	622,248.92	23,743.44	1,183.68	1,010.33	33,353.31	11,858.03	33,969.20	135,595.97	60,752.71			923,715.59	5,885.81
New Mexico	79,777.28	1,418.62	279.73	827.27	4,670.04	624.35	4,954.62	17,796.25	22,878.44	49,791.52	3,219.33	186,237.45	60,057.66
New York:													
Cornell	1,381,437.45	31,913.26	1,472.18	11,236.66	99,949.31	9,678.40	58,214.85	271,948.50	158,626.35	9,995.51		2,034,572.47	
State	600,600.81	10,824.75	1,507.26	4,193.68	7,755.81	10,882.23	16,813.32	67,482.57	35,193.68			755,254.11	

North Carolina	601,624.70	22,816.39	3,066.64	6,519.75	10,278.07	11,519.39	30,767.39	92,201.57	76,718.33	16,223.34		871,735.57	
North Dakota	220,477.92	9,609.93	1,503.99	2,158.20	4,334.80	9,673.42	38,063.32	76,285.09	66,986.33	55,760.95	2,858.44	487,712.39	75,427.62
Ohio	592,807.83	14,011.90	3,677.44	4,218.79	29,108.68	9,470.55	29,544.45	266,602.16	53,897.59	245,301.46		1,248,640.85	720,600.36
Oklahoma	415,901.79	17,154.70	2,812.42	2,896.21	16,474.80	9,361.27	41,863.93	170,839.74	48,100.75	5,845.53		731,251.14	422,739.07
Oregon	677,917.18	43,875.82	4,899.41	8,840.24	14,378.70	8,520.72	33,017.77	178,132.00	63,360.25		32,147.30	1,065,089.39	
Pennsylvania	581,727.99	34,285.53	1,135.55	2,348.12	8,257.72	11,687.61	10,043.94	160,337.93	93,559.23	56,484.05		959,867.67	56,061.17
Puerto Rico	263,677.10	5,230.72	2,514.35	2,594.77	8,948.26	5,065.16	3,372.07	90,037.85	30,915.29	6,765.00		419,120.57	218,946.86
Rhode Island	54,333.17	1,498.48	29.06	85.82		602.88	1,220.55	11,648.88	3,552.64			72,971.48	22,245.91
South Carolina	281,279.35	11,967.63	200.52	2,976.97	6,687.96	1,083.08	40,682.10	75,465.01	54,700.19	8,541.19		483,584.00	35,157.34
South Dakota	137,256.20	6,146.37	384.26	146.42	742.26	2,690.70	8,016.87	68,665.61	25,133.92			249,182.61	27,926.10
Tennessee	244,755.40	7,713.56	4,318.33	2,911.11	4,830.21	5,167.85	34,350.23	140,031.14	62,146.03	26,255.73		532,479.59	
Texas	997,945.57	29,481.24	4,403.83	10,690.16	24,302.45	6,010.53	171,891.46	268,416.92	249,498.62	198,409.85	27,513.30	1,988,563.93	555,212.93
Utah	214,513.89	15,656.36	2,450.85	2,872.84	6,773.54	10,090.81	10,270.61	61,892.50	41,497.69	18,947.68		384,966.77	16,616.02
Vermont	44,393.67	2,276.38	88.33	469.41	2,151.24	2,097.03	3,366.02	4,250.50	9,124.44	550.43	920.66	69,688.11	12,854.53
Virginia	323,392.10	23,590.96	1,404.04	5,376.11	9,263.72	1,316.25	15,417.27	70,728.71	60,646.15	60,242.46		571,377.77	108,444.42
Washington	814,726.85	46,614.74	6,732.94	7,190.52	12,533.94	15,086.84	54,961.35	166,275.95	202,188.76	96,273.96	26,885.25	1,449,471.10	
West Virginia	105,099.03	5,060.58	97.40	728.47	8,406.04	535.82	23,308.95	71,198.68	16,207.29	20,359.27		251,001.53	52,194.74
Wisconsin	1,417,808.00	28,948.00	3,287.00	2,651.00	6,777.00	9,431.00	55,661.00	275,499.00	23,332.00			1,823,394.00	
Wyoming	128,105.39	9,922.46	2,376.20	2,107.20	7,081.55	2,421.69	9,525.32	70,359.89	51,297.72	20,884.55		304,081.97	72,071.96
Total	24,240,181.71	980,199.90	135,715.92	227,518.96	599,869.10	406,828.81	1,659,254.75	6,710,646.77	3,324,751.99	1,913,060.92	106,479.55	40,304,508.38	5,390,291.29

TABLE 11.—*Summary of expenditures of the experiment stations for the year ended June 30, 1949*

Station	Federal-grant funds							Contractual Federal funds, Research and Marketing, Title II	Non-Federal funds	Grand Total
	Hatch	Adams	Purnell	Bankhead-Jones	Research and Marketing Title I		Total			
					Sections 9(b)1-9(b)2	Section 9(b)3				
Alabama	$15,000.00	$15,000.00	$60,000.00	$96,152.81	$79,340.05	$14,433.50	$279,926.36		$929,872.85	$1,209,799.21
Arizona	15,000.00	15,000.00	60,000.00	15,499.36	24,458.54	11,151.91	141,109.81		343,926.24	485,036.05
Arkansas	15,000.00	15,000.00	59,254.50	74,181.83	62,429.73	12,000.67	237,866.73		448,090.64	685,957.37
California	15,000.00	15,000.00	60,000.00	95,542.61	71,337.01	38,061.71	294,941.33	$630.00	3,843,248.15	4,138,819.48
Colorado	15,000.00	15,000.00	60,000.00	26,055.98	26,548.82	27,456.36	170,061.16		396,975.80	567,036.96
Connecticut:										
State	7,498.78	7,499.32	29,955.68	12,662.46	15,984.54		73,600.78		324,760.52	398,361.30
Storrs	7,500.00	7,500.00	30,000.00	13,129.28	12,847.30	5,573.00	76,549.58		300,650.38	377,199.96
Delaware	15,000.00	14,447.95	60,000.00	6,054.94	15,270.65	750.00	111,523.54		154,805.00	266,328.54
Florida	15,000.00	15,000.00	60,000.00	40,579.22	44,200.97	5,721.51	180,501.70		2,178,417.60	2,358,919.30
Georgia	15,000.00	15,000.00	60,000.00	101,476.80	80,522.21	18,966.75	290,965.76		280,733.78	571,699.54
Hawaii	15,000.00	14,885.91	60,000.00	10,269.39	19,222.48		119,377.78		463,507.07	582,884.85
Idaho	15,000.00	15,000.00	60,000.00	16,589.81	26,679.38	16,447.94	149,717.13		301,878.06	451,595.19
Illinois	15,000.00	15,000.00	60,000.00	100,946.87	68,881.16	16,232.40	276,060.43		1,646,788.04	1,922,848.47
Indiana	15,000.00	14,994.53	58,891.80	73,383.88	66,908.20	16,157.17	245,335.58		1,516,134.61	1,761,470.19
Iowa	15,000.00	15,000.00	60,000.00	74,752.37	66,192.94	72,305.88	303,251.19	728.54	1,130,991.74	1,434,971.47
Kansas	15,000.00	15,000.00	60,000.00	57,178.54	46,609.83	8,807.68	202,596.05		526,809.41	729,405.46
Kentucky	15,000.00	15,000.00	60,000.00	95,122.25	79,732.41	8,610.65	273,465.31		484,684.71	758,150.02
Louisiana	15,000.00	15,000.00	60,000.00	65,919.96	56,620.37	10,497.23	223,037.56		1,026,840.23	1,249,877.79
Maine	15,000.00	15,000.00	60,000.00	24,124.05	21,686.34	15,670.00	151,480.39		267,964.05	419,444.44
Maryland	14,866.58	15,000.00	59,979.27	35,303.01	33,868.81	10,655.65	169,673.32		318,956.56	488,629.88
Massachusetts	15,000.00	15,000.00	60,000.00	21,787.39	23,238.20	12,500.00	147,525.59		372,141.83	519,667.42
Michigan	15,000.00	15,000.00	60,000.00	85,827.73	68,962.31	15,746.90	260,536.94	2,463.42	720,746.65	983,747.01
Minnesota	15,000.00	15,000.00	60,000.00	66,813.91	53,092.85	21,008.21	230,914.97		1,425,045.95	1,655,960.92
Mississippi	15,000.00	15,000.00	60,000.00	84,569.98	66,418.42	31,820.09	272,808.49	2,480.87	1,227,461.94	1,502,751.30
Missouri	15,000.00	15,000.00	60,000.00	89,383.63	79,356.09	14,646.12	273,385.84		451,392.70	724,778.54
Montana	15,000.00	15,000.00	60,000.00	17,871.46	24,137.84	7,662.39	139,671.69		593,063.09	732,734.78
Nebraska	15,000.00	15,000.00	60,000.00	44,233.72	40,932.92	6,775.71	181,942.35		656,815.31	838,757.66
Nevada	15,000.00	15,000.00	60,000.00	3,190.40	14,130.07	2,100.00	109,420.47		55,080.72	164,501.19
New Hampshire	15,000.00	15,000.00	60,000.00	9,925.30	25,503.34	4,204.93	129,633.57		52,764.69	182,398.26

New Jersey	15,000.00	15,000.00	60,000.00	36,470.37	27,558.70	19,999.64	174,028.71	1,500.00	923,715.59	1,099,244.30
New Mexico	15,000.00	15,000.00	60,000.00	16,935.36	22,812.04	12,151.86	141,899.26	----------	186,237.45	328,136.71
New York:										
Cornell	13,494.43	13,500.00	53,939.68	99,200.58	51,570.93	43,309.35	275,014.97	----------	2,034,572.47	2,309,587.44
State	1,499.02	1,483.81	6,000.00	10,950.31	7,636.71	----------	27,569.85	150.44	755,254.11	782,974.40
North Carolina	15,000.00	15,000.00	60,000.00	123,766.51	95,491.45	30,105.05	339,363.01	----------	871,735.57	1,211,098.58
North Dakota	15,000.00	15,000.00	60,000.00	28,147.42	28,058.21	1,247.51	147,453.14	----------	487,712.39	635,165.53
Ohio	15,000.00	15,000.00	60,000.00	109,336.37	52,091.72	8,169.41	259,597.50	----------	1,248,640.85	1,508,238.35
Oklahoma	15,000.00	15,000.00	60,000.00	78,361.16	60,109.26	4,853.29	233,323.71	----------	731,251.14	964,574.85
Oregon	15,000.00	15,000.00	60,000.00	26,588.72	28,875.39	37,735.47	183,199.58	----------	1,065,089.39	1,248,288.97
Pennsylvania	15,000.00	15,000.00	60,000.00	157,876.48	94,597.45	12,241.51	354,715.44	----------	959,867.67	1,314,583.11
Puerto Rico	15,000.00	15,000.00	58,663.20	61,600.10	68,983.97	3,500.00	222,747.27	----------	419,120.57	641,867.84
Rhode Island	15,000.00	15,000.00	60,000.00	2,857.19	16,739.74	11,759.04	121,355.97	----------	72,971.48	194,327.45
South Carolina	15,000.00	15,000.00	60,000.00	69,224.19	49,891.64	23,238.13	232,353.96	----------	483,584.00	715,937.96
South Dakota	15,000.00	15,000.00	60,000.00	27,733.01	28,450.45	8,498.70	154,682.16	----------	249,182.61	403,864.77
Tennessee	15,000.00	15,000.00	60,000.00	89,992.09	81,640.49	12,605.16	274,237.74	----------	532,479.59	806,717.33
Texas	15,000.00	15,000.00	59,999.95	173,212.42	146,746.35	57,804.76	467,763.48	384.27	1,988,563.93	2,456,711.68
Utah	15,000.00	15,000.00	60,000.00	12,170.15	19,782.77	25,592.15	147,545.07	----------	384,966.77	532,511.84
Vermont	14,891.46	15,000.00	59,524.84	12,034.27	16,264.56	2,715.86	120,430.99	----------	69,688.11	190,119.10
Virginia	15,000.00	15,000.00	60,000.00	82,941.86	51,333.42	11,320.00	235,595.28	----------	571,377.77	806,973.05
Washington	15,000.00	14,357.32	59,785.89	38,795.24	40,843.55	28,601.77	197,383.77	----------	1,449,471.10	1,646,854.87
West Virginia	15,000.00	15,000.00	60,000.00	65,169.05	46,428.45	9,104.84	210,702.34	----------	251,001.53	461,703.87
Wisconsin	15,000.00	15,000.00	60,000.00	70,152.59	57,590.76	24,214.17	241,957.52	226.67	1,823,394.00	2,065,578.19
Wyoming	15,000.00	15,000.00	60,000.00	7,829.36	17,956.90	8,068.83	123,855.09	----------	304,081.97	427,937.06
Total	749,750.27	748,668.84	2,995,994.81	2,859,873.74	2,426,568.69	822,800.86	10,603,657.21	8,564.21	40,304,508.38	50,916,729.80

TABLE 12.—*Expenditures and allotments under the Research and Marketing Act of 1946, Title II, for the year ended June 30, 1949*

Station	Expenditures												Unexpended balance	Allotment
	Personal services	Travel	Transportation of things	Communication service	Rents and utility services	Printing and binding	Other contractual services	Supplies and materials	Equipment	Lands and structures (contractual)	Contributions to retirement	Total expenditures		
Alabama													$7,700.00	$7,700
California	$630.00											$630.00	270.00	900
Georgia													5,000.00	5,000
Iowa	210.00					$3.54		$237.00	$278.00			728.54	2,971.46	3,700
Maine													4,000.00	4,000
Michigan	1,620.19	$434.82		$2.61			$15.56	19.92	370.32			2,463.42	7,036.58	9,500
Mississippi	2,092.17	46.90	$82.58				83.63	174.09	1.50			2,480.87	4,819.13	7,300
New Jersey									1,500.00			1,500.00		1,500
New York (Cornell)													3,000.00	3,000
New York (State)								150.44				150.44	6,349.56	6,500
Oregon													6,000.00	6,000
Texas	142.50	241.77										384.27	4,015.73	4,400
Wisconsin	226.67											226.67	773.33	1,000
Total	4,921.53	723.49	82.58	2.61		3.54	99.19	581.45	2,149.82			8,564.21	51,935.79	60,500

SUBJECT INDEX

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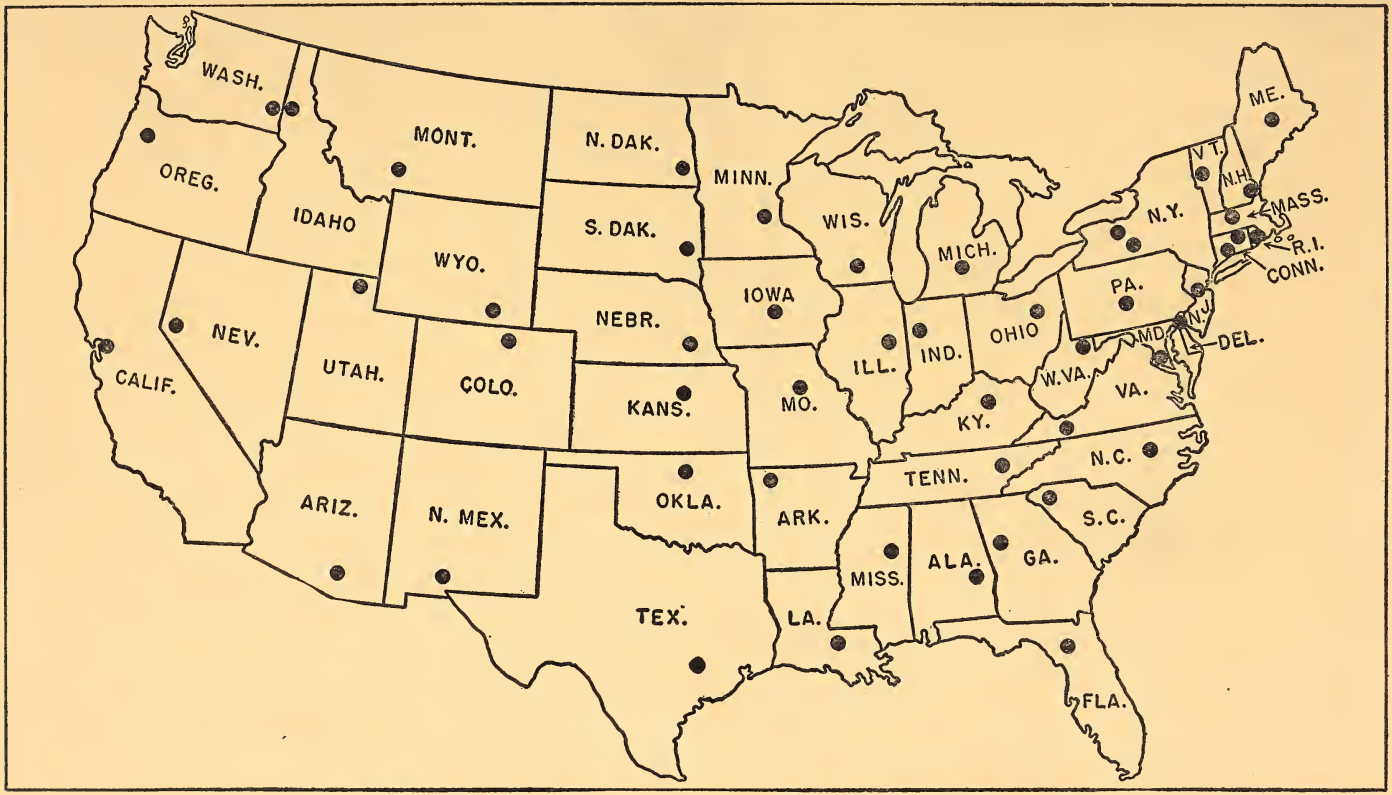
NOTE.—The full official titles, locations, and personnel of the agricultural experiment stations will be found in the list of Workers in Subjects Pertaining to Agriculture in Land-Grant Colleges and Experiment Stations, published by the United States Department of Agriculture.



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